TIMBER SUPPLY BRANCH

TIMBER SUPPLY REVIEW

Mackenzie Timber Supply Area Analysis Report

April 2001

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Mackenzie Timber Supply Area Analysis Report

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Preface

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This report contains a timber supply analysis and a socio-economic analysis and is part of the provincial Timber Supply Review carried out by the British Columbia Forest Service. The purpose of the review is to examine the short- and long-term effects of current forest management practices on the availability of timber for harvesting in timber supply areas (TSAs) and tree farm licences (TFLs) throughout British Columbia. A review of each TSA and TFL is completed at least once every five years.

To determine allowable timber harvesting levels accurately and rationally, the chief forester must have an up-to-date assessment of the timber supply based on the best available information and reflecting current management direction. **The report that follows provides only this assessment and should not be construed as a recommendation on permissible harvest levels.**

This report focuses on a single forest management scenario — current management practices. Current management practices are defined by the specifications in management plans for the timber supply area including guidelines for the protection of forest resources, the *Forest Practices Code (FPC) of British Columbia Act* and official land-use decisions made by Cabinet.

Assessing the implications of only current practices rather than looking at a number of different management schemes will expedite the analysis process, allowing analysis of all TSAs in the province every five years. An important part of these analyses is an assessment of how results might be affected by uncertainties — a process called sensitivity analysis. Together, the sensitivity analyses and the assessment of the effects of current forest management on the timber supply provide a basis for discussions among stakeholders about alternative timber harvesting levels.

In addition to having an up-to-date assessment of timber supply when setting the allowable annual cut (AAC), the chief forester considers short- and long-term implications of alternative harvest levels, capabilities and requirements of existing and proposed processing facilities, and the social and economic objectives of the Crown. The socio-economic analysis provides the chief forester with some of the information necessary for these considerations.

The socio-economic analysis considers forestry activity associated with the harvesting and processing of timber harvested from the TSA within the context of timber supply and production capacity of regional industry.

This report is the third of five documents that will be released for each TSA as part of the Timber supply review. The first two documents are the information report and the data package. This document provides technical information on the results of the timber supply and socio-economic analyses. A fourth document called the public discussion paper will summarize the technical information and will provide a focus for public discussions of possible timber harvest levels. Finally, the rationale document will outline the chief forester's harvest level decision and the reasoning behind it.

Executive Summary

As part of the provincial Timber supply review, the British Columbia Forest Service has examined the availability of timber in the Mackenzie Timber Supply Area (TSA). The analysis assesses how current forest management practices affect the supply of wood available for harvesting over the short- (next 20 years), medium- (21 to 80 years from now) and long- (beyond 80 years from now) terms. It also examines the potential changes in timber supply stemming from uncertainties about forest growth and management practices. The purpose of the timber supply analysis is to assess the timber supply implications of current forest management, and of uncertainties about land base, growth and yield, and practices associated with current management. **The forecasts in this report should be used for discussion purposes only; they are not allowable annual cut (AAC) recommendations.**

The Mackenzie TSA covers about 6.41 million hectares of land and water around Williston Lake in the north-central area of British Columbia. Approximately 4.77 million hectares of that area are productive forest, and about 1.45 million hectares are considered available for timber harvesting under current management practices. Lodgepole pine, white and Engelmann spruce and subalpine fir are the tree species most commonly harvested in the TSA. Forest practices in Mackenzie follow the standards and legislation set out by the *Forest Practices Code* as well as requirements of the Mackenzie Land and Resource Management Plan (LRMP) as approved by government in November 2000.

The results of this timber supply analysis suggest that short-term harvests can be maintained at the current AAC (2 997 363 million cubic metres per year). The medium- and long-term harvests could be increased to 3 305 000 cubic metres and maintained at that level over the analysis period (250 years). The analysis reflects current knowledge and information on forest inventory, growth and management.

However, uncertainty exists about several factors important in defining timber supply. A series of sensitivity analyses showed that these uncertainties could affect timber supply to varying degrees. Short-term (the next 20 years) timber supply is most sensitive to changes in the extent of the timber harvesting land base. The largest sensitivity would be including marginal stands which would increase the timber harvesting land base by 20.4% and the short-term harvest by 24%. The second-leading sensitivity would be including all deciduous-leading stands which would increase the timber harvesting land base by 3.3% and the harvest by 14% in the short term, and 3% in the long term.

Medium-term (21 to 80 years from now) timber supply is affected by estimates of timber volume in existing stands, the size of the timber harvesting land base and the previously mentioned factors that affect short-term timber supply. The largest potential negative effect results from potential reductions in estimates of timber volume in existing stands as indicated in a previous inventory audit. The effect in the medium term could be a reduction in available harvest of 11% or more.

The size of the timber harvesting land base was significantly increased when compared with the 1995 timber supply analysis. If a similar size timber harvesting land base is applied as within 1995, both the timber harvesting land base and the medium-term harvest level would be 20% lower. If the harvest from balsam-leading stands (8.4% of the timber harvesting land base) were limited, the medium term harvest level would be decreased by 4.9%. If marginal stands (4.5% of the timber harvesting land base) are not harvested, the medium- and long-term harvest levels would be 4% lower than in the base case. On the other hand if the far-zone marginal stands are harvested, the medium- and long-term harvest levels in the base case could be increased by about 13%. If the access to the far zone (4% of the timber harvest land base) were not available, the base case harvest level would be about 4% lower than in the base case. If grizzly bear management practices from the Mackenzie LRMP are applied, the medium-term harvest level would be 5% lower than the base case harvest level.

Long-term timber supply is sensitive to uncertainties in estimates of regenerated stand yields, estimates of site productivity for old-growth stands, management of deciduous-leading stands, as well as all factors with large potential effects on short- and medium-term timber supply mentioned previously (except for existing stand volume estimates). If site productivity were to increase to the level indicated in recent provincial research, the long-term harvest level could be increased by 24%.

Executive Summary

The socio-economic analysis for the Mackenzie TSA indicates that the current AAC of 2 997 363 cubic metres can support a provincial total of approximately 2,600 person-years of direct employment. Residents of the TSA account for approximately 69% of this direct employment. Direct forestry sector activity in the TSA supports a further 3,500 person-years of indirect and induced employment across the province.

The base case harvest forecast indicates that the current timber supply can be maintained. This harvest level will provide security for local processors and employees, and the community of Mackenzie. Given Mackenzie's high dependence on the forest sector, any substantial reduction to the timber supply or in milling capacity would negatively affect the community, both in local businesses and in social and other government-related services. This scenario is unlikely, however, as the timber supply is robust, not only in the Mackenzie TSA but also throughout the Prince George Forest Region.

The current AAC has provided the provincial government with average annual revenues of $105 million. Under the base case harvest forecast, annual revenues could increase by up to $16 million, mainly from increased stumpage revenues from a higher harvest volume.

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Introduction

Timber supply* is the quantity of timber available for harvest over time. Assessing the timber supply involves considering physical, biological, social and economic factors for all forest resource values, not just for timber. Physical factors include the land features of the area under study as well as the physical characteristics of living organisms, especially trees. Biological factors include the growth and development of living organisms. Economic factors include the financial profitability of conducting forest operations, and the broader community and social aspects of managing the forest resource.

All of these factors are linked: the financial profitability of harvest operations depends upon the terrain, as well as the physical characteristics of the trees to be harvested. Determining the physical characteristics of trees in the future requires knowledge of their growth. Decisions about whether a stand is available for harvest often depend on how its harvest could affect other forest values, such as wildlife or recreation.

These factors are also subject to both uncertainty and different points of view. Financial profitability may change as world timber markets change. Unforeseen losses due to fire or pest infestations will alter the amount and value of timber. The appropriate balance of timber and non-timber values in a forest is an ongoing subject of debate, and is complicated by changes in social objectives over time.

Thus, before an estimate of timber supply is interpreted, the set of physical, biological and socio-economic conditions on which it is based, and which define current forest management — as well as the uncertainties affecting these conditions — must first be understood. Timber supply analysis is the process of assessing and predicting the current and future timber supply for a management unit (a geographic area). For a timber supply area (TSA)*, the timber supply analysis forms part of the information used by the chief forester of British Columbia in determining an allowable annual cut (AAC)* — the permissible harvest level for the area.

Timber supply projections made for TSAs look far into the future — 250 years or more. However, because of the uncertainty surrounding the information and because forest management objectives change through time, these projections should not be viewed as static prescriptions that remain in place for that length of time. They remain relevant only as long as the information upon which they are based remains relevant. Thus, it is important that re-analysis occurs regularly, using new information and knowledge to update the timber supply picture. Indeed, the *Forest Act* requires that the timber supply for management units through British Columbia be reviewed at least every five years. This allows close monitoring of the timber supply and of the implications for the AAC stemming from changes in management practices and objectives.

**Throughout this document, an asterisk after a word or phrase indicates that it is defined in a box at the foot of the page, as well as in the glossary.*

Timber supply
The amount of timber that is forecast to be available for harvesting over a specified time period, under a particular management regime.

Timber supply area (TSA)
An integrated resource management unit established in accordance with Section 7 *of the* Forest Act.
Allowable annual cut (AAC)
The rate of timber harvest permitted each year from a specified area of land, usually expressed as cubic metres of wood per year.

Introduction

Timber supply analysis involves three main steps. The first is collecting and preparing information and data in which the B.C. Forest Service forest inventory* plays a major role. The second step is using these data along with a timber supply computer model or models* to project or estimate possible harvest levels over time. These projections are made using different sets of assumed values or conditions for the factors discussed above. The third step is interpreting and reporting results.

The following sections outline the timber supply analysis for the Mackenzie TSA. Following a brief description of the area in Section 1, data preparation and formulation of assumptions are discussed in Section 2. Timber supply analysis methodology and results are presented in Sections 3 and 4, respectively. Section 5 examines the sensitivity of the results to uncertainties in the data and assumptions used. This is followed by a summary and conclusions for the timber supply analysis in Section 6. Section 7 shows results of a socio-economic analysis for the Mackenzie TSA. Appendixes A and B contain further details about the data and assumptions used in the analysis.

As part of the timber supply review, information is gathered on the short- and long-term implications of alternative harvest levels, and the capabilities and requirements of existing and proposed processing facilities. The socio-economic analysis provides information for the chief forester and the local community to better understand the potential magnitude of impacts associated with any proposed harvest level changes.

The socio-economic analysis considers the current and projected levels of forestry activity associated with the Mackenzie TSA within the context of regional timber supplies and production capacity. It does this by examining the profile of the region and the local forest industry; and by assessing employment and income implications of the timber harvesting levels projected in the base case.

The analysis includes estimates of the employment and income impacts associated with timber supply analysis projections by three main sectors: harvesting and other woodlands-related, processing, and silviculture. Employment is measured in person-years*. Employment income is calculated using average industry income estimates.

Data on direct employment, harvest levels and fibre flows were obtained by surveying licensees and mill operators. The information was used to estimate harvesting, processing and silviculture direct employment averages associated with the harvest and the proportion of workers living in the area. The estimates of local and provincial harvesting, processing, and silviculture direct employment were then used to determine ratios of employment per 1000 cubic metres of timber harvested.

Forest inventory
An assessment of British Columbia's timber resources. It includes computerized maps, a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, and a description of other forest values such as recreation and visual quality.

Model
An abstraction and simplification of reality constructed to help understand an actual system or problem. Forest managers and planners have made extensive use of models, such as maps, classification systems and yield projections, to help direct management activities.

Person-year(s)
One person working the equivalent of one full year, defined as at least 180 days of work. Someone working full-time for 90 days accounts for 0.5 person-years.

Introduction

Indirect and induced employment figures were calculated using the Mackenzie TSA and provincial employment multipliers* developed by the Ministry of Finance and Corporate Relations. Indirect impacts result from direct businesses purchasing goods and services; induced impacts result from direct employees purchasing goods and services. Employment coefficients* per 1000 cubic metres were also determined for the indirect and induced impacts.

To estimate the level of employment that could be supported by alternative harvest rates, projected timber supply levels were multiplied by the calculated employment coefficients. Note that employment coefficients are based on current productivity, harvest practices and management assumptions* and will not likely reflect industry conditions decades into the future. As such, the employment estimates can only be viewed as general indicators.

Employment multiplier
An estimate of the total employment supported by each direct job, for example a multiplier of 2.0 means that one direct job supports one additional indirect and induced job.

Employment coefficient
The number of person-years of employment supported by every 1000 cubic metres of timber harvested; for example, a coefficient of 1.0 indicates that every 1000 cubic metres harvested supports one person-year, or 500 000 cubic metres supports 500 person-years.

Management assumptions
Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specification of minimum harvestable ages, utilization levels, integrated resource guidelines and silviculture and pest management programs.

1 Description of the Mackenzie Timber Supply Area

The Mackenzie Timber Supply Area (TSA) is situated in the northeast interior of British Columbia and covers approximately 6.41 million hectares, making it the fourth largest TSA in the province. This TSA is one of six in the Prince George Forest Region and is administered from the Mackenzie forest district office in Mackenzie. The TSA is part of the Mackenzie Forest District, which also includes extensive parks and protected areas*.

The topography of the Mackenzie TSA is variable. The Rocky Mountain Trench, with its flat to gentle terrain, runs north-south through the centre of the TSA. To the east are the rugged Rocky Mountains and to the west are the more rounded Omineca Mountains. Williston Lake — a narrow 360-kilometre long lake created by the WAC Bennett Dam on the Peace River — is one of the most prominent geographical features in the area.

Despite the diverse terrain of mountains and river valleys, the forests of the Mackenzie TSA are fairly homogeneous. Within the land base currently considered available for timber harvesting, lodgepole pine stands dominate about 44% of the area, spruce 38%, subalpine fir 15%, and deciduous* species 3.7%. The dominant feature of the climate in this TSA is cold weather. Daily average temperatures are below freezing for half of the year and three-quarters of the annual precipitation falls as snow.

About 71% of the Mackenzie TSA land base is considered Crown forest land managed by the B.C. Forest Service (approximately 4.5 million hectares). This includes 1.78 million hectares of protected areas and the Special Resource Management: Wildland zone, where timber harvesting is not permitted. Currently about 53% of the Crown forest land is considered available for harvesting (23% of the total TSA land base).

The current allowable annual cut (AAC) in the Mackenzie TSA is 2 997 363 cubic metres. This level was set in 1996 by the chief forester, and includes a 50 000 cubic metres partition* for predominantly deciduous stands.

Significant changes that influence forest management have occurred since the last timber supply review was completed. These changes include:

- implementation of the *Forest Practices Code (FPC)**;
- reclassification of the operability* map;
- formal establishment of interim landscape units* and biodiversity* emphasis options;
- designation of scenic corridors; and
- establishment of protected areas and the Special Resource Management Wildland zone.

The Mackenzie TSA is sparsely populated. About 95% of the estimated population of 6,360 (1996 census) live in the community of Mackenzie. Other small settlements include Germansen Landing and Manson Creek, and the First Nations communities of Fort Ware and Tsay Keh. There is very little dispersed rural settlement within the TSA.

Protected area
A designation for areas of land and water set aside to protect natural heritage, cultural heritage or recreational values (may include national park, provincial park, or ecological reserve designations).
Deciduous
Deciduous trees commonly have broad-leaves and usually shed their leaves annually.
Partition
A portion of the AAC that is attributable to certain types of timber and/or terrain.
Forest Practices Code
Legislation, standards and guidebooks that govern forest practices and planning, with a focus on ensuring management for all forest values.

Operability
Classification of an area considered available for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.
Landscape unit
A planning area based on topographic or geographic features, that is appropriately sized (up to 100 000 hectares), and designed for application of landscape-level biodiversity objectives.
Biodiversity (biological diversity)
The diversity of plants, animals and other living organisms in all their forms and levels of organization, including the diversity of genes, species and ecosystems, as well as the evolutionary and functional processes that link them.

1 Description of the Mackenzie Timber Supply Area

In 1994, the Mackenzie Land and Resource Advisory Table was formed to make recommendations on proposed new protected areas. In August 1996, this task was incorporated into a formal Land and Resource Management Plan (LRMP)* process for the Mackenzie TSA. The LRMP process provides an opportunity for First Nations, the public, interest groups and government to make recommendations regarding protected areas and future forest management of public lands in the TSA. The LRMP was signed-off by the planning table in June 2000 and approved by government in November 2000. Portions of it are expected to be incorporated as a Higher Level Plan* later in 2001. The new protected areas and the Special Resource Management: Wildland zone created as a result of the LRMP have been fully incorporated in the timber supply analysis.

The forests of the Mackenzie TSA provide a wide range of forest land resources, including forest products, recreational opportunities, minerals, tourism amenities and a variety of wildlife habitats. Trapping and guide-outfitting also have a long history in the area. Recreational use of the forests of the TSA is increasing. The lakes, rivers and mountainous terrain offer a wide range of front- and back-country recreational opportunities, including mountain biking, hiking, fishing, camping, wildlife viewing, boating, heli-skiing, snowmobiling, and cross-country and downhill skiing. Outdoor recreation mainly occurs in the southern part of the TSA, near B.C. Forest Service recreation sites on the shores of Williston Lake. Other popular recreation areas include Bijoux Falls Provincial Park, Kennedy Siding Recreation Site, Germansen Lake Recreation Site and, during the winter, Powder King Ski Village.

Land and Resource Management Plan (LRMP)
A strategic, multi-agency, integrated resource plan at the subregional level. It is based on the principles of enhanced public involvement, consideration of all resource values, consensus-based decision making, and resource sustainability.

Higher level plans
Higher level plans establish the broader, strategic context for operational plans, providing objectives that determine the mix of forest resources to be managed in a given area.

1 Description of the Mackenzie Timber Supply Area

Figure 1. Map of the Mackenzie Timber Supply Area, Prince George Forest Region.

1 Description of the Mackenzie Timber Supply Area

1.1 The environment

The five biogeoclimatic zones* that occur in the Mackenzie TSA reflect the diversity of climates and vegetation in the area. The varied ecological features and unique nature of the area contribute to the high biodiversity values found in this TSA.

The Boreal White and Black Spruce (BWBS) zone occurs at lower elevations in valleys mainly in the northern and western portion of the TSA, up to about 1300 metres. The BWBS is characterized by long, very cold winters and short growing seasons. The main tree species are white spruce, lodgepole pine and trembling aspen. Black spruce, balsam poplar, subalpine fir and birch also occur.

The Sub-Boreal Spruce (SBS) zone adjoins the BWBS zone, occurring from valley bottoms to about 1300 metres, mainly in the southern portion of the TSA. The climate of this zone is characterized by severe, snowy winters and relatively warm, moist and short summers. Hybrid white spruce and subalpine fir are the dominant climax tree species, while lodgepole pine, aspen and birch are often found as early seral* species.

The Spruce Willow Birch (SWB) zone is the most northerly subalpine zone in British Columbia and has the harshest climate of all the forested zones in the province. Winters are long and cold, and summers are brief and cool. The SWB is located at middle elevations of the Rocky and Omineca mountains in the northern part of the Mackenzie TSA, above the BWBS zone. At lower elevations of this zone, the dominant species are white spruce and subalpine fir, with black spruce, lodgepole pine and trembling aspen also occurring. Upper elevations of this zone are dominated by subalpine fir; black spruce, lodgepole pine and aspen are relatively minor species.

The Engelmann Spruce Subalpine Fir (ESSF) zone is the uppermost forested zone in much of the Mackenzie TSA, typically occurring above the SBS zone and the more southerly part of the BWBS zone and below the Alpine Tundra zone. The ESSF has a relatively cold, moist and snowy continental climate. Growing seasons are cool and short, while winters are long and cold. Engelmann spruce and subalpine fir are the dominant climax tree species, while lodgepole pine is common after fires.

The Alpine Tundra (AT) zone occurs extensively at high elevations above the ESSF zones, occupying about one-third of the Mackenzie TSA. The climate is cold, windy and snowy with a short, cool growing season. By definition this zone is treeless and vegetation is dominated by shrubs, herbs, mosses and lichens. Much of the alpine landscape lacks vegetation and is the domain of rock, ice and snow.

The diverse forests and the many streams, rivers and lakes in this TSA are home to over 250 species of wildlife, including mule and whitetailed deer, grizzly bears, black bears, moose, woodland caribou, wolves, coyotes, Stone sheep, elk and mountain goats. Furbearers include marten, lynx, beaver, otter and fisher. Fisheries productivity is low mainly due to the cold climate, but rainbow trout, bull trout, lake trout, arctic grayling, whitefish and kokanee are found in the waterways of the TSA.

Under the *Forest Practices Code*, a process exists for identifying species at risk and designating wildlife habitat areas with specific management practices. The wildlife species that have been declared Identified Wildlife in the seven main ecosections of the Mackenzie Forest District are presented in Table 1.

Biogeoclimatic zones
A large geographic area with broadly homogeneous climate and similar dominant tree species.

Early seral
Stands are defined as early seral if they are younger than 40 years of age. An exception is deciduous-dominated stands in the Boreal White and Black Spruce biogeoclimatic zone, which are defined as early seral up to 20 years of age.

1 Description of the Mackenzie Timber Supply Area

Table 1. Species at risk identified under the Forest Practices Code

Common names of identified wildlife	Ecosection						
	Hart Ranges	Misinchinka Ranges	Manson Plateau	Parsnip Trench	South Omineca Mtns.	Western Muskwa Ranges	Cassiar Ranges
Bull trout	x	x	x	x	x	x	x
American bittern			x		x		
Trumpeter swan	x	x	x	x	x	x	x
Northern goshawk *atricapillus*	x	x	x	x	x	x	x
Sandhill crane					x		
Fisher	x	x	x	x	x	x	x
Grizzly bear	x	x	x	x	x	x	x
Mountain goat		x	x		x	x	x

Source: *Forest Practices Code of British Columbia - Managing identified wildlife: Procedures and measures, Volume 1.*, February 1999.

Current forest management practices follow the legislation and guidelines set out by the *Forest Practices Code*. Consequently, the protection of wildlife and the environment are managed through the Code. In addition, the provincial government has adopted as policy the Mackenzie LRMP which provides direction regarding protected areas and management practices.

1.2 First Nations

Nine First Nations have asserted traditional territory within the Mackenzie TSA. The traditional territories of the Kwadacha and the Tsay Keh Dene First Nations are almost entirely located within the TSA, including their main communities of Fort Ware and Tsay Keh, respectively. The traditional territories of the McLeod Lake, Takla Lake, Nak'azdli, West Moberly and Halfway River First Nations are primarily located outside the TSA but portions of their traditional territories overlap with the TSA. In addition, small portions of the TSA near Thutade Lake are asserted to be within the traditional territories of the Gitxsan and the Tahltan First Nations.

The McLeod Lake First Nation and the federal and provincial governments have reached an agreement where all parties will adhere to Treaty 8. This information will be considered in this timber supply review. When other treaty negotiations or agreements are concluded, they will be considered in future timber supply reviews.

1 Description of the Mackenzie Timber Supply Area

Forestry is the main source of employment for most First Nation members in the Mackenzie TSA, including work in harvesting, silviculture, cone collection and fire suppression. Trapping, fishing and guiding are also important activities. First Nations in the Mackenzie TSA depend heavily on hunting, fishing and gathering natural foods for sustenance. They have expressed concern about increasing road access and associated increased hunting pressures that may reduce game populations.

A preliminary Archaeological Overview Assessment (AOA) has been completed for the Mackenzie TSA. To provide a better basis for determining areas and sites that may require further assessment, this AOA is expected to be modified in 2001. When warranted, archaeological inventories are conducted to identify potential sites and Archaeological Impact Assessments (AIA) are carried out to enable modification of operational plans and forest practices to protect cultural heritage resources*.

Cultural heritage resource
An object, a site or the location of a traditional societal practice that is of historical, cultural or archaeological significance to the province, a community or an aboriginal people.

2 Information Preparation for the Timber Supply Analysis

Information required for timber supply analysis can be divided into three general categories: land base inventory, timber growth and yield and management practices.

2.1 Land base inventory

The various sources of land base information used in this analysis were compiled into one computer file in the year 2000 by the Ministry of Forests. This file contains information on the forest land in the Mackenzie TSA including general geographic location, area, nature of forest cover (such as number and type of trees, age and timber volume), and other characteristics such as environmental sensitivity and physical accessibility (operability). Stand attributes such as tree height, stocking* and age have been projected to 1999. The inventory file has been updated to account for timber harvesting up to 1999 for the Mackenzie TSA.

The inventory file represents the land base for the entire TSA. It includes information on land that does not contain forest, and other areas where timber harvesting is not expected to occur. Examples are land set aside for parks, areas needed to protect wildlife habitat, areas in utility and transportation corridors, and residential and industrial development. A description of these areas specific to the Mackenzie TSA is provided in the following. These types of areas do not contribute to the timber harvesting land base* of the Mackenzie TSA. Before assessing timber supply, these non-contributing areas are identified and separated from the timber harvesting land base.

Identifying areas as not contributing to timber supply does not mean the area is removed from the Mackenzie TSA. The B.C. Forest Service still manages the entire area of the TSA (except for designated areas under the jurisdiction of other agencies) as a land unit that contributes a mix of timber and non-timber values. The timber supply is managed within this integrated resource context, and the analysis described herein is consistent with this philosophy.

This section describes the types of areas that do not contribute to the timber harvesting land base. Use of the term "timber harvesting land base" in this report does not mean the area is open to unrestricted logging. Rather, it implies that forests in the area contain timber of sufficient economic value, and sites of adequate environmental resilience, to accommodate timber harvesting with due care for other resources.

Stocking
The proportion of an area occupied by trees, measured by the degree to which the crowns of adjacent trees touch, and the number of trees per hectare.

Timber harvesting land base
Crown forest land within the timber supply area where timber harvesting is considered both acceptable and economically feasible, given objectives for all relevant forest values, existing timber quality, market values and applicable technology.

2 Information Preparation for the Timber Supply Analysis

For the Mackenzie TSA, the following types of areas were excluded from the timber harvesting land base.

- not managed by Crown —non-Crown areas (such as private land) and other areas that are not administered as part of the TSA (e.g., woodlots). The forested portions of parks and ecological reserves contribute towards biodiversity values.
- non-forest areas — areas not occupied by productive forest cover (e.g., rock, swamp, alpine areas and water bodies).
- protected area and wildland areas — areas designed under the LRMP as protected areas and wildland.
- non-commercial cover areas — areas occupied by non-commercial tree or brush species.
- inoperable areas* — areas classified as unavailable for harvest for terrain-related or economic reasons. Characteristics used to define operability include slope and topography (e.g., presence of gullies or exposed rock).
- existing unclassified roads, trails and landings — areas of forest land that have been removed from timber production due to access development and harvesting to date.
- special planning cell — areas with special management objectives.
- environmentally sensitive areas (ESA)* — portions of the areas considered environmentally sensitive and/or significantly valuable for other resources.
- balsam marginal stands — areas defined by the forest district as balsam-leading marginal stands.
- spruce marginal stands — areas defined by the forest district as spruce-leading marginal stands and all black spruce leading stands.
- pine marginal stands — areas defined by the forest district as pine-leading marginal stands.
- deciduous-leading stands — portions of deciduous-leading stands in near zone south of Peace Arm.
- deciduous-leading stands — all deciduous-leading stands in far zone and near zone north of Peace Arm are generally not used in this TSA.
- problem forest types* (PFT) — stands that are physically operable and exceed low site or low volume criteria yet are not currently utilized or have marginal merchantability.
- sites with low volume — old forest areas occupied by forest with volume below the threshold of economically operable.
- sites with low timber productivity — young forest areas occupied by forest with low timber-growing potential.

Inoperable areas
Areas defined as unavailable for harvest for terrain-related or economic reasons. Characteristics used in defining inoperability include slope, topography (e.g., the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality. Operability can change over time as a function of changing harvesting technology and economics.

Environmentally sensitive areas
Areas with significant non-timber values, fragile or unstable soils, impediments to establishing a new tree crop, or high risk of avalanches.
Forest type
The classification or label given to a forest stand, usually based on its tree species composition. Pure spruce stands and spruce-balsam mixed stands are two examples.

- Kemess power line — areas occupied or will be used for Kemess power line.
- Kemess mine site — areas occupied by the Kemess mine.
- riparian areas* — areas otherwise available for timber production, a portion of which is assumed to be unavailable for harvesting to protect riparian and stream ecosystems.
- wildlife tree* patch areas — areas reserved within and along the edges of cutblocks* for the maintenance of stand-level biodiversity* (stand structure), primarily for conservation or enhancement of wildlife.

A more detailed description of these categories, including specific criteria for removal is located in Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis."

Table 2 summarizes the areas in each category, and shows the area of the timber harvesting land base. The column "Crown forest area by classification" provides the total forest area managed by the B.C. Forest Service within the given category. For example, while there is a total of 448 216 hectares of forested land classified as environmentally sensitive area (ESA) outside of community watersheds*, only 353 483 hectares were removed specifically due to environmental sensitivity. The difference arises because one area can be in more than one classification (e.g., inoperable and ESA), and the actual area deducted depends on the point at which the reduction occurs in the sequence. Further, partial reductions are sometimes used to represent situations where parts of areas are retained to protect a particular value.

Riparian area
Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.
Wildlife tree
A standing live or dead tree with special characteristics that provide valuable habitat for conservation or enhancement of wildlife.

Cutblock
A specific area, with defined boundaries, authorized for harvest.
Stand-level biodiversity
A stand is a relatively localized and homogeneous land unit that can be managed using a single set of treatments. In stands, objectives for biodiversity are met by maintaining specified stand structure (wildlife trees or patches), vegetation species composition and coarse woody debris levels.
Watershed
An area drained by a stream or river. A large watershed may contain several smaller watersheds.

2 Information Preparation for the Timber Supply Analysis

Table 2. Determination of the timber harvesting land base for the Mackenzie TSA

Classification	Crown forest area by classification	Area (hectares)	Per cent of total TSA area	Per cent of Crown forest land
Total TSA area		6 410 643	100	
Not managed by the Crown		246 929	3.9	
Non-forest		1 635 867	25.5	
Total forest area managed by the Crown		**4 527 847**	**70.6**	
Protected area and wildland		1 776 066	27.7	
Crown forest:		**2 751 781**	42.9	**100**
Reductions:				
Non-commercial forest	32 425	32 425	0.5	1.2
Inoperable areas	4 207	3 181	0.05	0.1
Current roads, trails and landings		9 463	0.1	0.3
Special planning cell	19 550	19 515	0.3	0.7
Environmentally sensitive areas (ESAs)	448 216	353 483	5.5	12.8
Balsam marginal stands	308 204	227 566	3.5	8.3
Spruce marginal stands	77 068	34 576	0.5	1.3
Pine marginal stands	212 975	86 940	1.4	3.2
Deciduous north Peace Arm	76 285	14 561	0.2	0.5
Deciduous far haul zone	105 433	80 426	1.3	2.9
Problem forest types (PFT)	116 372	20 270	0.3	0.7
Sites with low volume	552 265	180 516	2.8	6.6
Sites with low productivity	127 513	62 342	1.0	2.3
Kemess power line	2 030	2 030	0.03	0.1
Kemess mine site	1 450	1 450	0.02	0.1
Riparian areas		116 372	1.8	4.2
Wildlife tree patch (WTP) area		60 267	0.9	2.2
Total current reductions		1 305 383	20.4	47.4
Current timber harvesting land base (including 38 741 hectares not satisfactorily restocked (NSR)*)		**1 446 398**	**22.6**	**52.6**
Future land base changes				
Future road reductions		65 088	1.0	2.4
Long-term timber harvesting land base		**1 381 130**	**21.5**	**50.2**

Not satisfactorily restocked (NSR) areas
An area not covered by a sufficient number of well-spaced tree stems of desirable species. Stocking standards are set by the B.C. Forest Service. Areas harvested prior to October 1987 and not yet sufficiently stocked according to standards are classified as backlog NSR. Areas harvested or otherwise disturbed since October 1987 are classified as current NSR.

2 Information Preparation for the Timber Supply Analysis

The current timber harvesting land base in the Mackenzie TSA represents about 22.6% of the total TSA area and about 52.6% of the forest area managed by the B.C. Forest Service (Crown forest).

Figure 2, which represents the total Mackenzie TSA area and the Crown forested land base, respectively, shows that 45.6% of the total land base is classified as non-Crown forest (not managed by B.C. Forest Service, non-forest, or protected area and wildland). The remaining Crown forested area (54.4%) is detailed showing the categories of forest land unavailable for harvesting (47.4%). The main reasons for unavailability are physical or economic inoperability and environmental sensitivity. Approximately 52.6% of the Crown forest is considered available for timber harvesting (including NSR) now or in the future. All marginal stands (stands with low economic value for harvesting) are summed together under problem forest type.

The current timber harvesting land base is 1 446 398 hectares, which is 25% larger than in the last timber supply review. The major factor in increasing the timber harvesting land base is the reclassification of land which was previously considered inoperable.

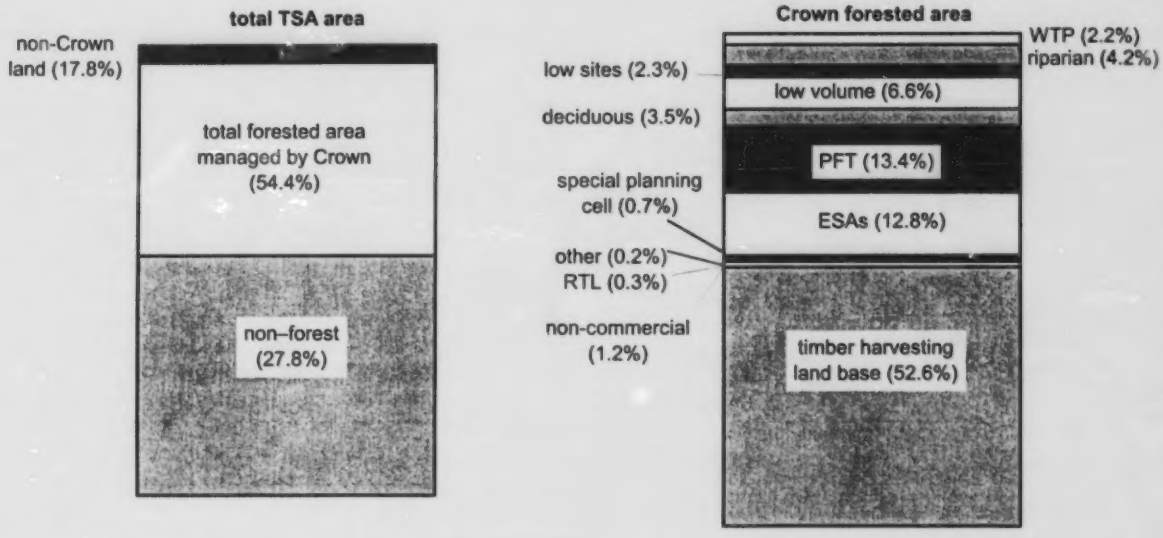

Figure 2. Composition of the total and Crown forested land bases — Mackenzie TSA, 2001.

TSA = timber supply area
B.C.F.S. = British Columbia Forest Service
RTL = roads, trails and landings
PFT = problem forest types
ESAs = environmentally sensitive areas
WTP = wildlife tree patch

2 Information Preparation for the Timber Supply Analysis

Figure 3 shows overall distribution of biogeoclimatic (BEC) variants* in the Crown forested area in the TSA. Also shown is the proportion of each BEC variant that is in the timber harvesting land base. For example, the BWBSdk1 variant makes up 11.1% of the Crown forested area and the forested portions of provincial parks, while 34.6% of the total area of BWBSdk1 is within the timber harvesting land base. The ESSFmv3 variant makes up 9.7% of the Crown forested area and the forested portions of provincial parks, while 51.7% of the total area of ESSFmv3 is within the timber harvesting land base.

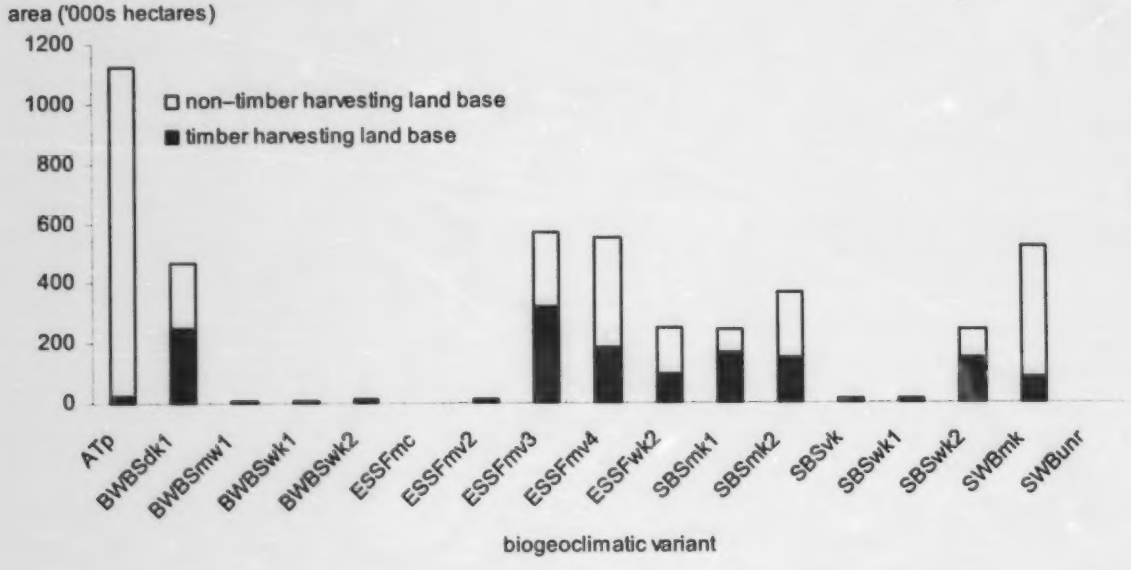

Figure 3. Forested area by biogeoclimatic classification — Mackenzie TSA, 2001.

Biogeoclimatic (BEC) variant
A subdivision of a biogeoclimatic zone. Variants reflect further differences in regional climate and are generally recognized for areas slightly drier, wetter, snowier, warmer or colder than other areas in the subzone.

2 Information Preparation for the Timber Supply Analysis

Figure 4 shows the current composition of the timber harvesting land base by dominant tree species. Pine dominates stands on about 43.8% of the timber harvesting land base, with spruce dominating on 38%, balsam 14.5% and deciduous 3.7%. After harvest, most stands are expected to be regenerated to the same species, except the balsam sites, which will be regenerated to pine and spruce mixed stands.

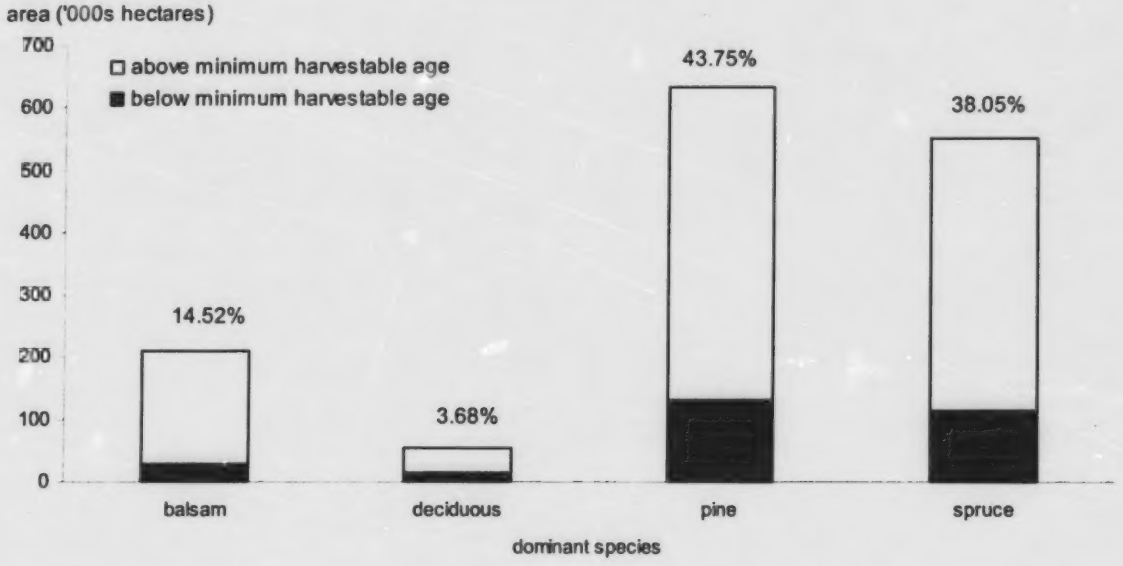

Figure 4. Area by dominant species — Mackenzie TSA timber harvesting land base, 2001.

Figure 4 also shows the proportion of area of each species that is either younger or older than the minimum harvestable age (see Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis" for details on the minimum harvestable age for each species). In total, about 80% of stands in the timber harvesting land base are at or above the minimum harvestable age. There is variation around this proportion for each of the species groupings: 79.3% of pine stands, 79.3% of spruce stands, 86.3% of balsam stands and 71.6% of deciduous stands are currently older than the minimum harvestable age.

Given the different proportions of area below minimum harvestable age for each species group, harvesting and salvage operations in the Mackenzie TSA have concentrated mostly on pine, followed by spruce and balsam. As noted previously, balsam stands have been converted to pine and spruce mixed stands after harvest, which adds immature area to these categories, and expands the indicated harvesting in these stand types.

2 Information Preparation for the Timber Supply Analysis

Figure 5 shows the distribution of site productivity of the dominant stand types within the timber harvesting land base. More than 25% of the stands are classified as having relatively good site productivity. Stands with medium site productivity occupy 50% of the area, and those with relatively poor site productivity, 25%. Most sites of very low productivity (producing less than 140 cubic metres per hectare by age 140 years) are excluded from the timber harvesting land base. Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis" contains a definition of good, medium and poor site productivity for each of the species groups shown in Figure 5.

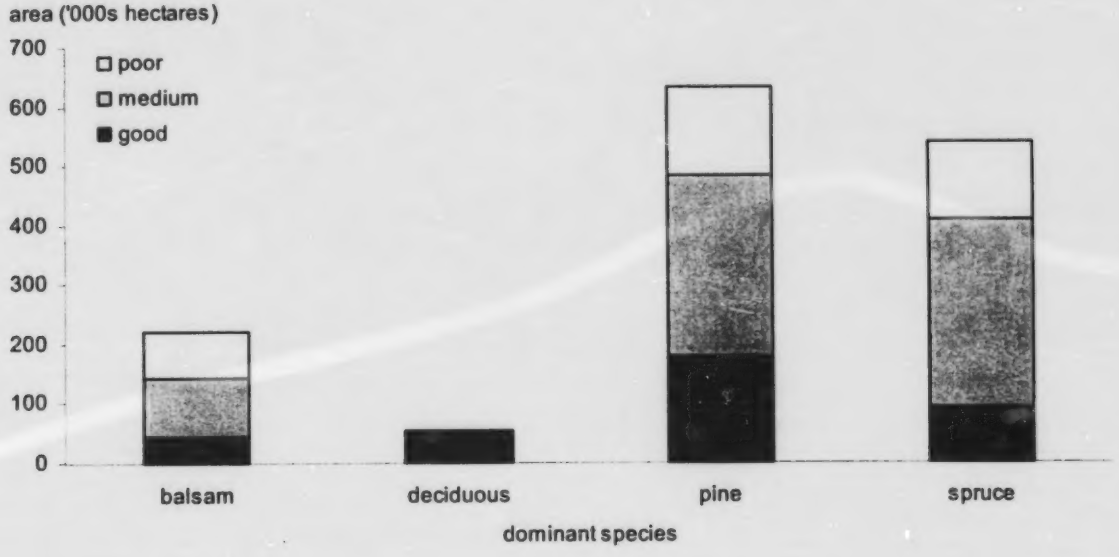

Figure 5. *Area by predominant species and site productivity — Mackenzie TSA timber harvesting land base, 2001.*

2 Information Preparation for the Timber Supply Analysis

Figure 6 shows the current age composition of all Crown forested area and the forested portions of provincial parks in the Mackenzie TSA. Currently, about 7% of stands in the total forested area are 20 years or younger, 25% are between 21 and 100 years old, 63% are between 101 and 250 years of age and 5% are older than 250 years. In the timber harvesting land base almost 80% of the stands are at or above the minimum harvestable age applicable to the stand. In the timber harvesting land base 11% of the stands are 20 years or younger, 26% are between 21 and 100 years old, 58% are between 101 and 250 years of age and 5% are older than 250 years.

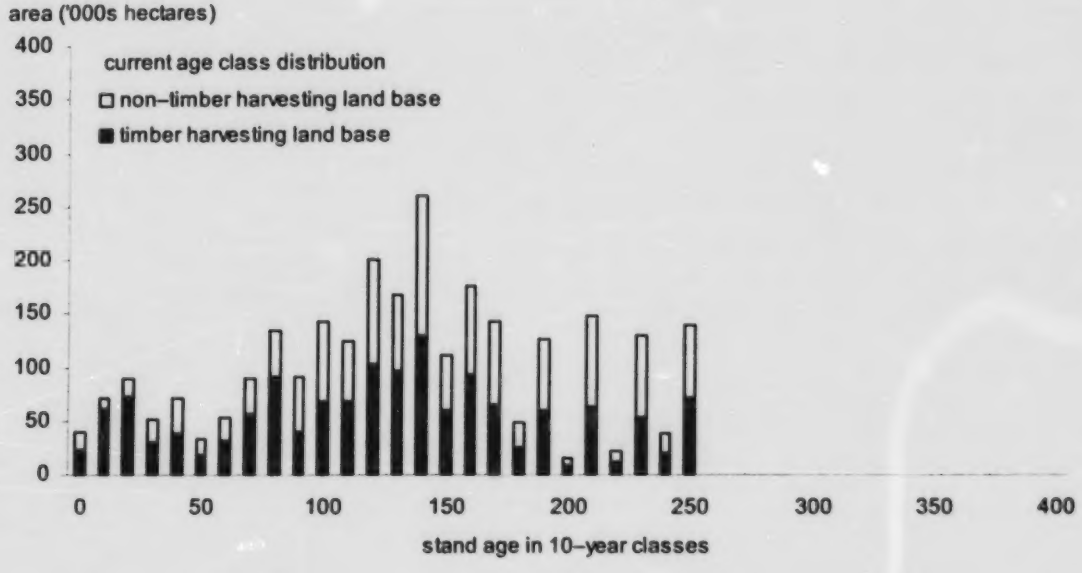

Figure 6. Current age class composition — Mackenzie TSA forested land base, 2001.

The age class distribution of forested stands excluded from the timber harvesting land base also affects timber supply. In the case of the Mackenzie TSA, 47% of the total forest land base is covered by these stands. Although these stands do not contribute directly to the timber supply, they can affect how much harvesting can be conducted and the pattern of the harvesting within the TSA by providing old-forest and biodiversity attributes. Four per cent of the stands are 20 years or younger, 22% are between 21 and 100 years old and 70% are between 101 and 250 years of age. Only 4% of these "non-timber harvesting land base" stands are older than 250 years.

2 Information Preparation for the Timber Supply Analysis

2.2 Timber growth and yield

Timber growth and yield refers to the prediction of the growth and development of forest stands over time. Forest stands have many characteristics that change over time that could be the subject of growth and yield (for example, number of trees per area, tree diameter, tree height and species composition). Since timber supply analysis concentrates on timber volumes available over time, the most relevant measure for this analysis is volume per area (in British Columbia, cubic metres per hectare). An estimate of timber volume in a stand assumes a specific utilization level, or set of dimensions, those establish the minimum tree and log sizes that are removed from a site. Utilization levels used in estimating timber volumes specify minimum diameters both near the base and the top of a tree.

Two growth and yield models were used to estimate timber volumes for the Mackenzie TSA analysis. The variable density yield prediction (VDYP)* model developed by the B.C. Forest Service, Resources Inventory Branch, was used for estimating volumes in unmanaged coniferous* stands and managed and unmanaged deciduous stands. The table interpolation program for stand yields (TIPSY)*, developed by the B.C. Forest Service, Research Branch was used to estimate yields for coniferous managed stands. Managed stands were defined as 100% of pine-spruce, pine and spruce existing stands less than 13 years of age; 60% from age 13 to age 40; and all stands that will be established in the future.

Volume estimation and prediction is subject to uncertainty due to the procedures used for estimating site productivity, limited experience with second growth in British Columbia and the long time frame over which trees grow. Sensitivity analyses described in Section 5, "Timber Supply Sensitivity Analyses," address the possibility that actual timber volumes may be different from estimates used in this analysis.

Based on timber volume estimates*, the current timber inventory on the timber harvesting land base is approximately 306.8 million cubic metres. About 297.6 million cubic metres, or 97% of the total, are currently merchantable; that is, older than minimum harvestable age. The merchantable volume of forests currently greater than 140 years old is approximately 185.4 million cubic metres.

2.3 Management practices

Timber supply depends directly on how the forest is managed for both timber and non-timber values. Therefore, levels of management activity must be defined for the timber supply analysis. The *Forest Practices Code of British Columbia Act* guides forest management practices in the Mackenzie TSA. The focus of the timber supply review is to assess timber supply based on current management practices as implemented in plans for the area. Staff in the Mackenzie Forest District described management practices as follows:

- Silviculture practices — reforestation activities required to establish free-growing* stands of acceptable tree species. Most areas in the Mackenzie TSA are harvested using a clearcut harvesting* system and restocked by planting.

Variable Density Yield Prediction model
An empirical yield prediction system supported by the B.C. Forest Service, designed to predict average yields and provide forest inventory updates over large areas (i.e., Timber Supply Areas). It is intended for use in unmanaged natural stands of pure or mixed composition.
Coniferous
Coniferous trees have needles or scale-like leaves and are usually 'evergreen'.
Table Interpolation Program for Stand Yields
A B.C. Forest Service computer program used to generate yield projections for managed stands using a model that simulates the growth of individual trees based on internal growth processes, crown competition, environmental factors and silvicultural practices.

Volume estimates (yield projections)
Estimates of yields from forest stands over time. Yield projections can be developed for stand volume, stand diameter or specific products, and for empirical (average stocking), normal (optimal stocking) or managed stands.
Free-growing
An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.
Clearcut harvesting
A harvesting method in which all trees are removed from an area of land in a single harvest. The harvested site is then regenerated to acceptable standards by appropriate means including planting and natural seeding. Note that retention of some live trees and snags for purposes of biodiversity now occurs on most clearcuts.

- Incremental silviculture — where necessary, stands are spaced early in their development to ensure young trees are well distributed to maximize growth. Improved seed from seed orchards is used when possible to increase productivity. There is currently limited availability of seedlings originating from seed orchards in the Mackenzie TSA; however, there are plans to increase the production for future planting.
- Forest health and unsalvaged losses* — timber losses to fire and pest (insect) damage are expected to average 172 800 cubic metres per year.
- Utilization levels — minimum sizes of trees, and logs to be removed during harvesting.
- Patch-size distribution and green-up* — in the Mackenzie TSA, approval of harvesting activities is contingent on previously harvested stands reaching a desired condition, or green-up (three metres in height for integrated resource management (IRM)* areas), before adjacent stands may be harvested. The purpose of patch-size distribution guidelines is to have a variety of different-sized openings spread across the landscape.
- Caribou habitat was protected by ensuring that only 5% of the area identified as caribou habitat was covered by forest less than 10 years old. For Morfee landscape unit and Misinchinka landscape unit not more than 33% of the area identified as caribou habitat was covered by forest less than 80 years.
- Grizzly bear habitat was modelled by ensuring that the area identified as habitat regenerated to natural stands after harvest, with a regeneration delay* of five years.
- Protection of environmentally sensitive areas — areas where potentially unstable soils, avalanche tracks, recreation activities, forest regeneration problems and habitat for various wildlife have been identified. To maintain ecological or other resource values, land has been partially or wholly removed from the timber harvesting land base.
- Maintenance of scenic values — maintaining important scenic values requires that visible evidence of harvesting be kept within limits in some areas of the Mackenzie TSA. The maximum proportion of each scenic area* that may be covered by young stands that do not meet green-up requirements varies depending on the forest characteristics and the visual quality class (VQC) for each area. In areas classified as VQC retention, 3% may be less than three metres tall; in partial retention class, 10%; in modification class, 20% and in maximum modification class, 32.5%.

Unsalvaged losses
The volume of timber killed or damaged annually by natural causes (e.g., fire, wind, insects and disease) and not harvested.
Green-up
The time needed after harvesting for a stand of trees to reach a desired condition (usually a specific height) — to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics — before harvesting is permitted in adjacent areas.
Integrated resource management (IRM)
The identification and consideration of all resource values, including social, economic and environmental needs, in resource planning and decision-making.

Regeneration delay
The period of time between harvesting and the date at which an area is occupied by a specified minimum number of acceptable well-spaced trees.
Scenic area
Any visually sensitive area or scenic landscape identified through a visual landscape inventory or planning process carried out or approved by a district manager.

- Minimum harvestable ages (MHA) — the time it takes for stands to grow to a merchantable condition. The criteria used to define minimum harvestable ages varied depending on district haul zones and logging systems. In the near zone stands should have, on average, a volume of at least 140 cubic metres per hectare and the trees should have a minimum diameter at breast height of 25 centimetres for conventional harvesting and 200 cubic metres per hectare and 28 centimetres for cable logging. In the far zone the requirement for volume is 160 cubic metres per hectare for conventional and 250 cubic metres per hectare for cable. For unmanaged stands the diameter criterion was an average of all stems whereas for managed stands the diameter criterion was an average of the largest 250 stems per hectare. Actual harvest age may be greater but not less than the minimum, and will depend on ages of other available stands, forest cover objectives* and overall timber harvest targets.
- Landscape-level biodiversity* — to maintain biological diversity throughout a landscape unit, the *Forest Practices Code* contains targets for the proportion of the area in each biogeoclimatic variant that should be covered by stands with old- and mature-forest characteristics. The Mackenzie Forest District has not formally completed the process of establishing landscape units and biodiversity emphasis options for biogeoclimatic variants within the Mackenzie TSA. The forest district currently has interim landscape units in place with biodiversity emphasis options for forest development plan purposes for two thirds of the TSA. The interim BEO's were incorporated into the base case. The rest of the TSA used the draft landscape unit emphasis options (see Section A.4.10, "Forest cover objectives" in Appendix A for details regarding landscape-level biodiversity).

The data package for the Mackenzie Timber Supply Area (TSA) was released in April 2000. As a result of public input, changes were made to the data package (e.g., the percentage reduction for existing roads, trails and landings). The revised data package, which includes detailed descriptions of the management practices and the assumptions used to incorporate them into the analysis, is presented in Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis", of this document.

Forest cover objectives
Specify desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest cover objectives (see Green–up).

Landscape-level biodiversity
The Landscape Unit Planning Guide *provides objectives for maintaining biodiversity at both the landscape level and the stand level. At the landscape level, guidelines are provided for the maintenance of seral stage distribution, patch size distribution and landscape connectivity.*

Figure 7 shows the proportions of the timber harvesting land base according to the forest management objectives for those areas. An area managed for an objective such as visual quality objective (VQO)* partial retention includes non-timber harvesting land base as well as timber harvesting land base. The percentages shown in Figure 7 are only for the timber harvesting land base portion of that management objective.

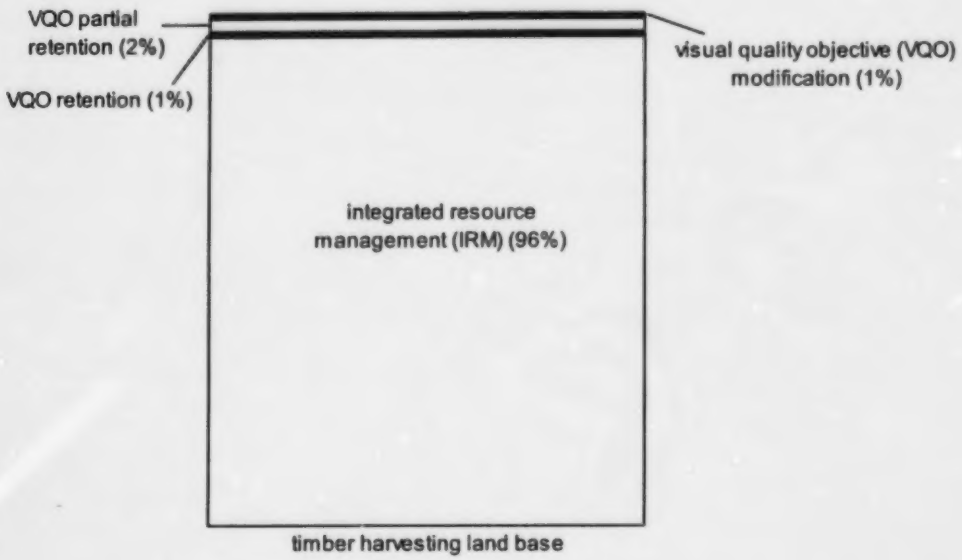
VQO partial retention (2%)
VQO retention (1%)
visual quality objective (VQO) modification (1%)
integrated resource management (IRM) (96%)
timber harvesting land base

Figure 7. Timber harvesting land base by management emphasis — Mackenzie TSA timber harvesting land base, 2001.

Visual quality objective (VQO)
Defines a level of acceptable landscape alteration resulting from timber harvesting and other activities. A number of visual quality classes have been defined on the basis of the maximum amount of alteration permitted.

3 Timber Supply Analysis Methods

The Forest Service Simulator (FSSIM) model version 3.0 was used for this analysis. The simulation model uses information about the timber harvesting land base, timber volumes, and the management regime to represent how trees grow and are harvested over a long period of time. Generally, only the results for the first 250 years are shown graphically in this report because the harvest level remains constant after that time.

Similar to other models, the FSSIM model assumes that trees grow according to provided yield projections and are harvested according to either a volume target or a specified objective set by the analyst, such as harvest volume maximization. FSSIM also allows the use of forest cover guidelines that specify the desired age composition of the forest. These guidelines can be used to examine the effects of green-up prescriptions and requirements for older forest. For example, guidelines might specify that no more than some maximum percentage of the forest can be younger than a specified green-up age, or that some minimum percentage of the forest must be in older age classes to provide wildlife habitat.

This type of analysis is used to determine the timber supply implications of a particular forest management regime. The results of the analysis are especially important in determining allowable cuts that will not restrict options of future resource managers, and that will assist local B.C. Forest Service staff to administer their programs according to relevant guidelines and principles. However, the results of the analysis are not meant to be taken as recommendations of any particular AAC.

The main results of the analysis are forecasts of potential timber harvests and timber inventory changes (ages and volumes) over time. Although this information gives field staff only limited guidance in the design of operational activities such as harvesting block location and silviculture planning, it does help ensure that the timber harvest level supports rather than hinders sustainable forest management in the field.

4 Results

This section presents results of the timber supply analysis for the Mackenzie TSA. The base case harvest forecast* uses the most recent assessments of current forest management, the land available for timber harvesting, and timber yields as described in Section 2, "Information Preparation for the Timber Supply Analysis." Because forest management is inherently a long-term venture, uncertainty surrounds much of the information important in determining timber supply. This uncertainty will be discussed in Section 5, "Timber Supply Sensitivity Analyses." The base case provides only a part of the timber supply picture for the Mackenzie TSA, and should not be viewed in isolation of the sensitivity analysis*.

4.1 Base case and alternative flow harvest forecasts

The current AAC for the Mackenzie TSA is 2 997 363 cubic metres per year. The base case forecast maintained the current harvest level for two decades before rising to the long-term harvest level* of 3 305 000 cubic metres per year at decade 3. The medium- and long-term harvest levels are 10% higher than the current harvest level. Figure 8 shows the base case harvest forecast for the Mackenzie TSA.

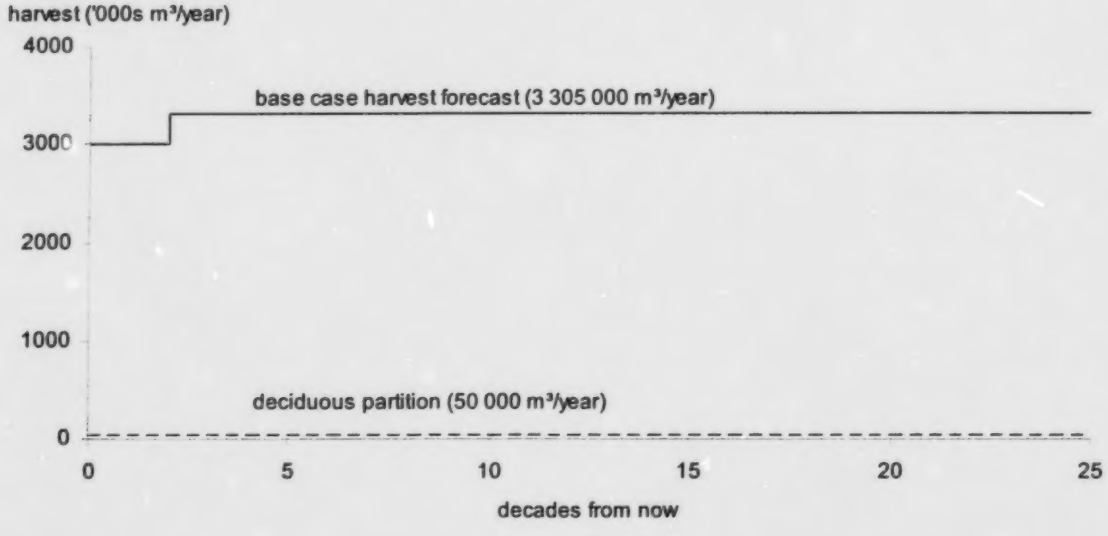

Figure 8. Base case harvest forecast for the Mackenzie TSA, 2001.

Base case harvest forecast
The timber supply forecast which illustrates the effect of current forest management practices on the timber supply using the best available information, and which forms the reference point for sensitivity analysis.

Sensitivity analysis
A process used to examine how uncertainties about data and management practices could affect timber supply. Inputs to an analysis are changed, and the results are compared to a baseline or base case.

Long-term harvest level
A harvest level that can be maintained indefinitely given a particular forest management regime (which defines the timber harvesting land base, and objectives and guidelines for non-timber values) and estimates of timber growth and yield.

4 Results

Unsalvaged losses due to natural forces such as insects and fire are estimated to be 172 800 cubic metres per year and have been subtracted from all harvest forecasts* shown in this report.

The base case harvest forecast shown in Figure 8 was developed subject to several assumptions. For example, the initial harvest level was established at the current allowable annual cut. The harvest level shown for deciduous was based on the current partition in the Mackenzie TSA.

Figure 9 compares two alternative forecasts with the base case. In both forecasts, the amount of harvest ascribed to deciduous partition remains constant at 50 000 cubic metres per year. Inputs related to land base, growth and yield and management remain constant in all forecasts in Figure 9.

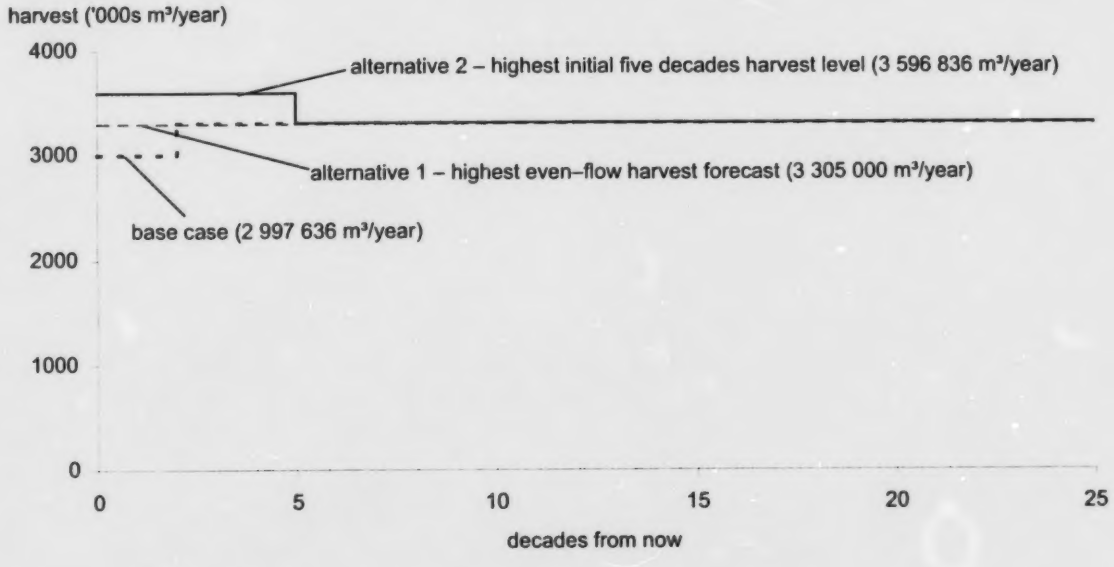

Figure 9. Alternative harvest flows — Mackenzie TSA, 2001.

Maximum even-flow harvest level

- Short-term harvest level is about 10% higher than the current AAC.
- Transition of harvesting from existing stands to managed, regenerated stands begins to occur in approximately decade 10, compared with decade 11 in the base case.

Higher initial five decades harvest forecast (alternative 2)

- First five decades harvest is the maximum achievable harvest level.
- Initial harvest level is 3 596 836 cubic metres per year, 20% above the base case initial harvest level and 10% above the maximum even-flow harvest level.
- Long-term harvest level is the same as the base case.
- Starting level is limited only by the amount of growing stock* that must be reserved until second-growth stands reach harvestable age.

Harvest forecast
The flow of potential timber harvests over time. A harvest forecast is usually a measure of the maximum timber supply that can be realized over time for a specified land base and set of management practices. It is a result of forest planning models and is affected by the size and productivity of the land base, the current growing stock, and management objectives, constraints and assumptions.

Growing stock
The volume estimate for all standing timber at a particular time.

4 Results

4.1.1 Base case timber supply dynamics

As shown in Figures 4 and 6, the forest in both the timber harvesting land base and the non-timber harvesting land base is unevenly distributed across age classes with 80% at or above the minimum harvestable ages. Figure 10 shows a transition of harvest from existing natural stands to managed stands for the base case starting at decade 11. By decade 13 the contribution from managed stands comprises more than 82% of the total harvest from the Mackenzie TSA.

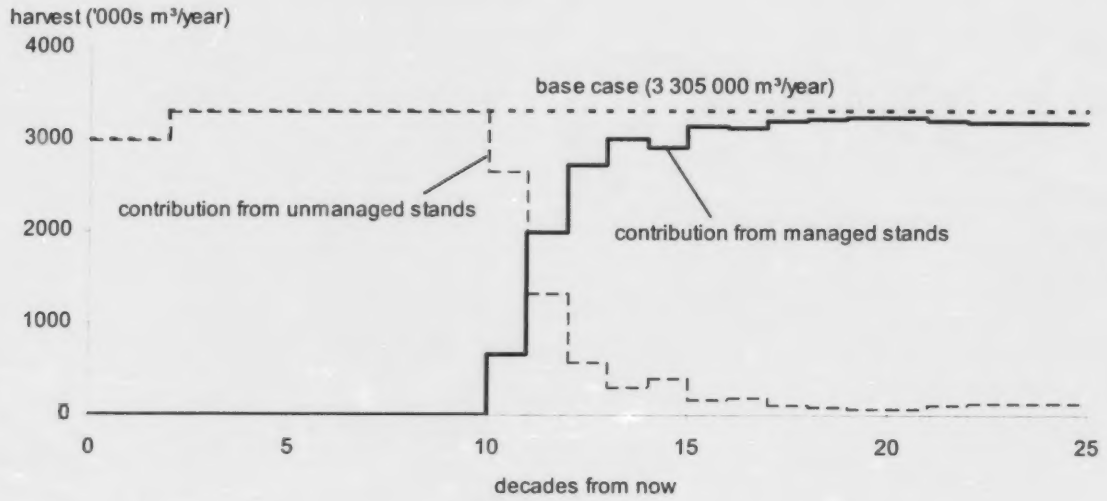

Figure 10. Harvest contribution from unmanaged and managed stands — Mackenzie TSA, 2001.

4 Results

Figure 11 tracks the growing stock of managed stands and of existing natural stands. The availability of merchantable timber from unmanaged stands allows the base case to maintain the same harvest level until decade 10, even though at that time managed stands comprise about 50% of the merchantable growing stock. Existing unmanaged stands still contribute to the merchantable growing stock well into the future largely because of the slow rate of harvest from retention and partial retention visual quality areas as well as the old-growth constraints for biodiversity on the timber harvesting land base. Some managed stands become merchantable as early as decade 5 but are not harvested until decade 10.

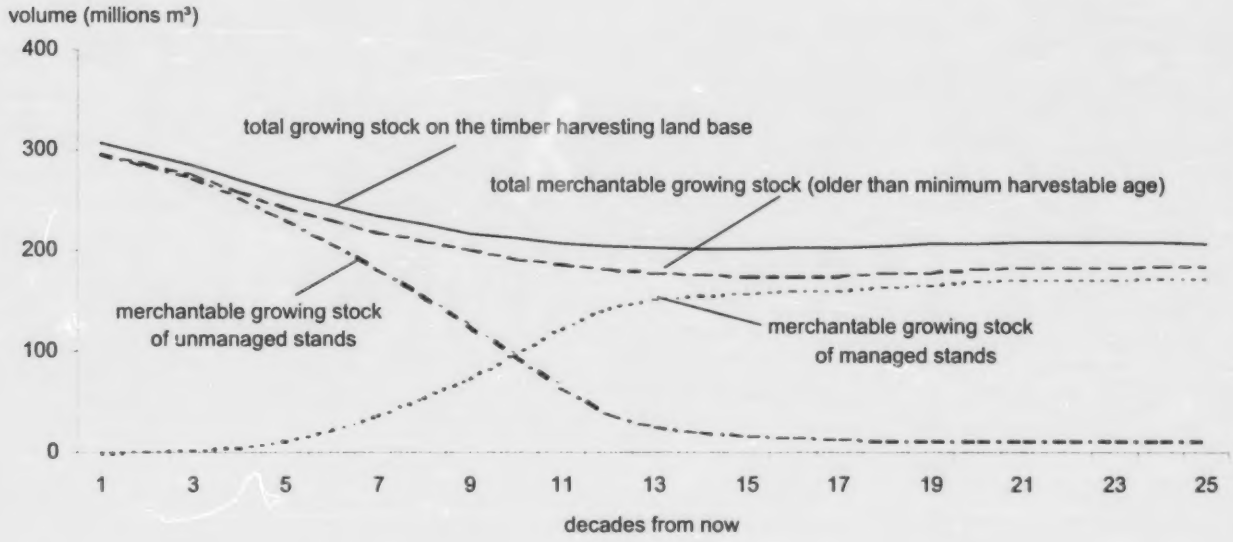

Figure 11. Total and merchantable growing stocks — Mackenzie TSA, 2001.

4 Results

4.2 Average age, area, and volume harvested

Figure 12 tracks the change in the volume-weighted average harvest age resulting from the base case forecast. The pattern of harvested age over the first eleven periods reflects that highest harvest priority during modelling was given to stands furthest above their minimum harvestable age and mostly the existing unmanaged stands. The average harvest age is relatively smooth and the impact from the green-up constraints and old-growth constraints are not significant. From decade 13 onwards, the harvested timber mostly comes from the managed and regenerated stands. The volume-weighted average harvest age for the regenerated stands decreases around 120 years.

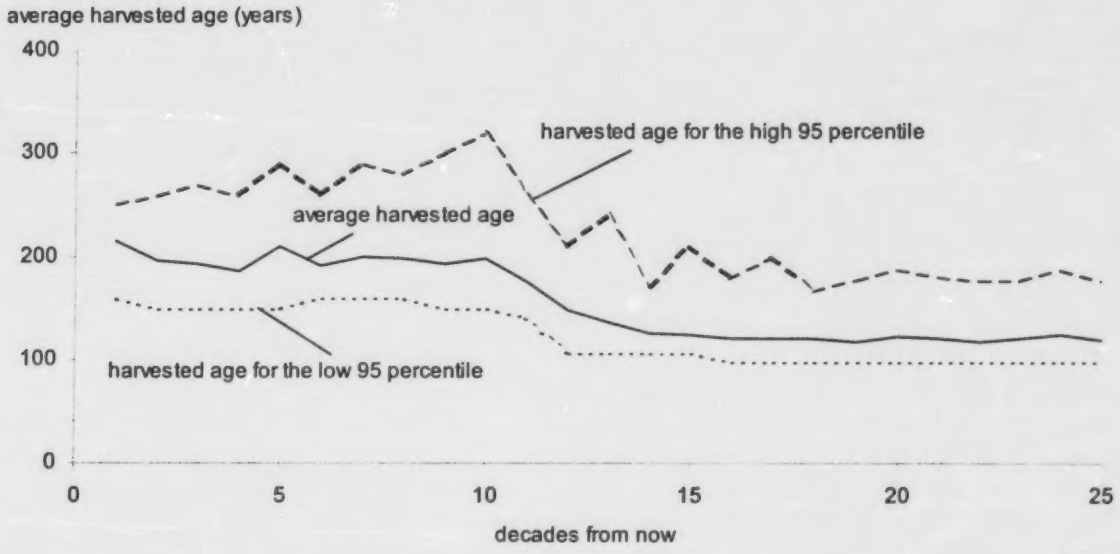

Figure 12. Average age of stands harvested over time — Mackenzie TSA base case, 2001.

4 Results

Figure 13 shows the average volume per hectare and average area harvested per year over the next 250 years under the base case harvest forecast. For the first 10 decades, while the timber supply is forecast to come mainly from unmanaged stands, the average volume per hectare varies from 316 to 332 cubic metres per hectare. After decade 10 when the timber supply is forecast to come mainly from managed stands, the average volume per hectare varies from 318 to 361 cubic metres per hectare. The area harvested varies slightly from 9478 hectares at decade 1 to 10 997 hectares at decade 3. The slightly higher area harvested from decades 2 to 12 is due to the existing stands with lower productivity and volume being harvested at that time.

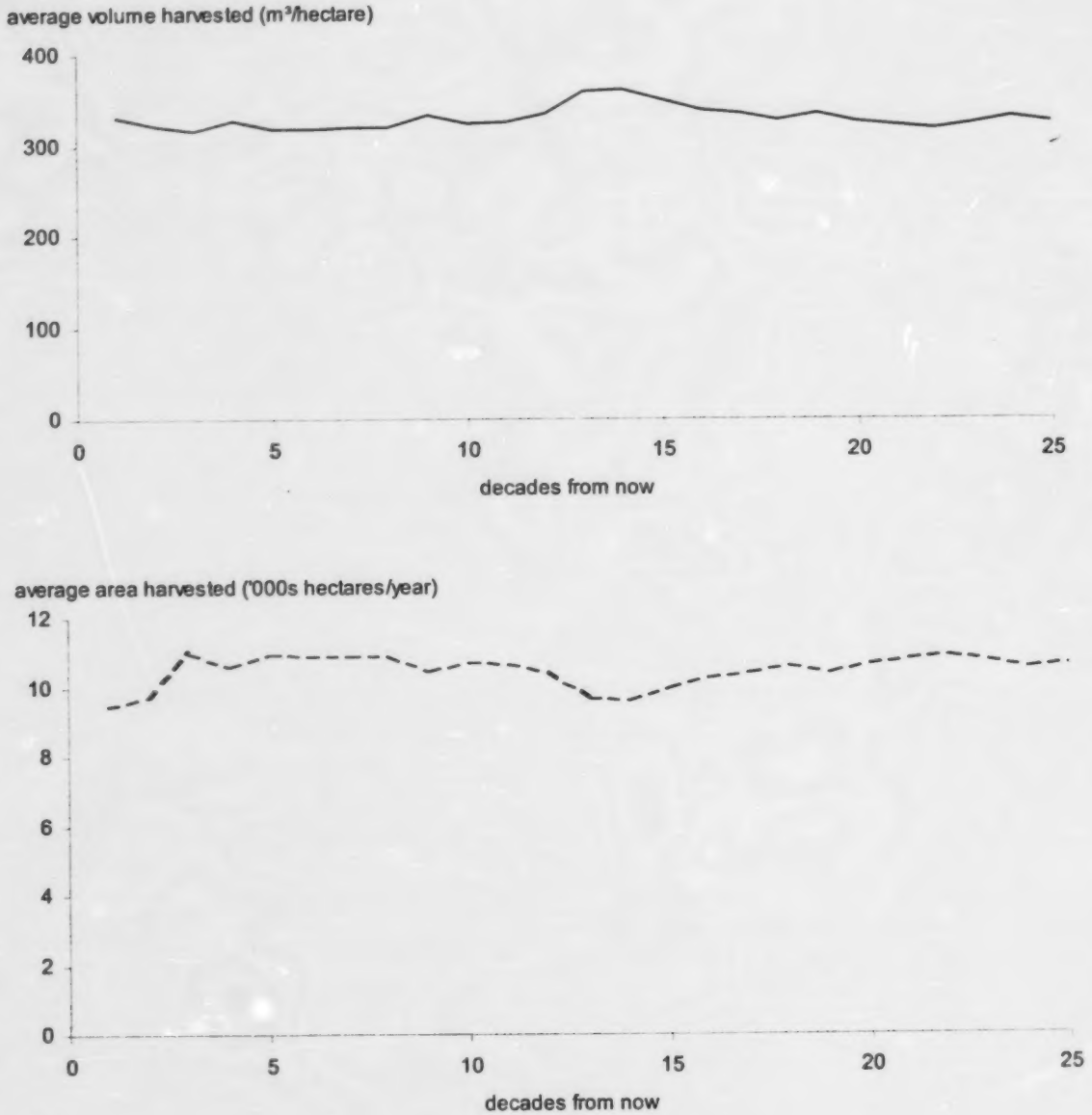

Figure 13. Average area harvested and average volume per hectare harvested over time — Mackenzie TSA base case, 2001.

4 Results

4.3 Age class profile over time

The charts in Figure 14 show how the age composition of the forest both in the timber harvesting land base and in the non-timber harvesting land base of the Mackenzie TSA change over time under the base case harvest forecast. In order to make smaller differences discernible among most classes, the vertical axis does not cover the full range of values in the last chart that displays the area distribution at 250 years from now. The oldest age class contains 512 000 hectares.

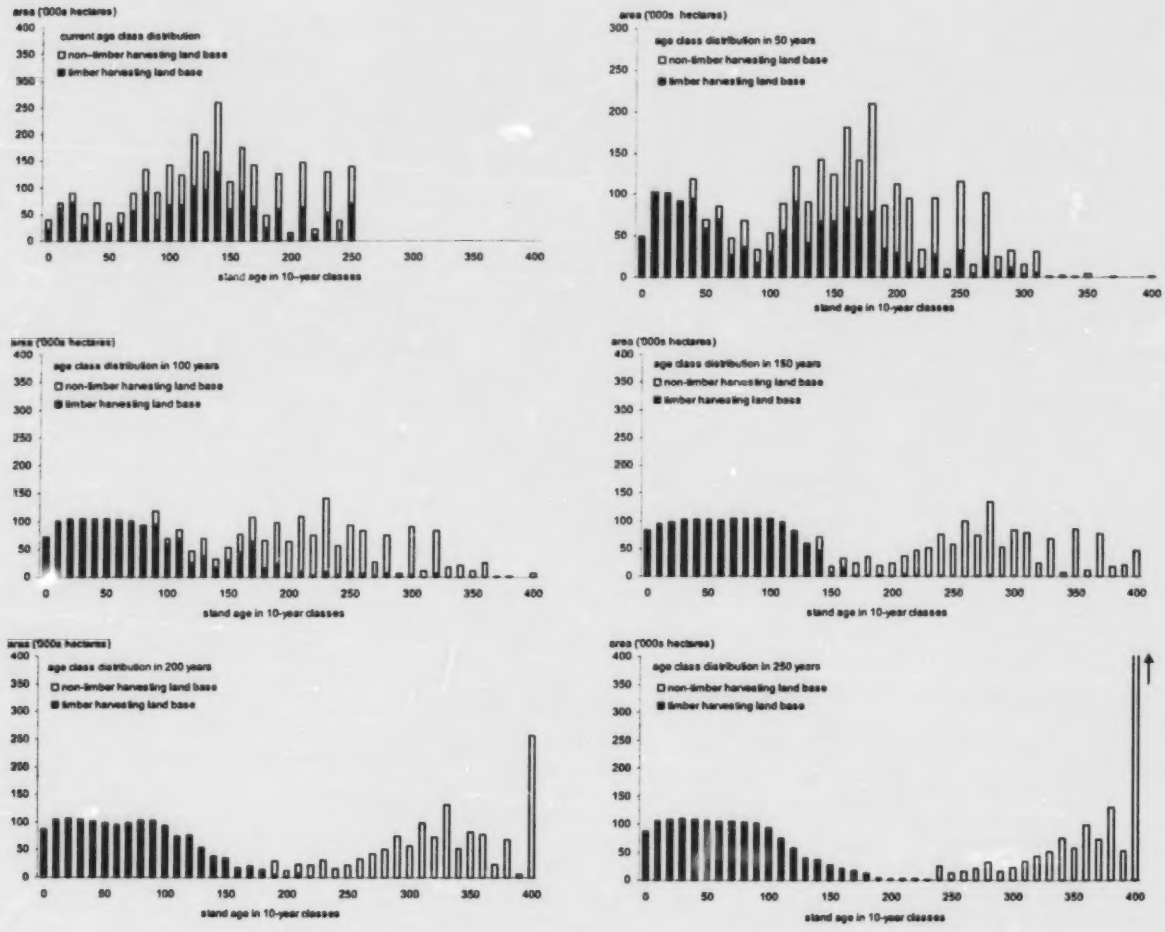
area ('000s hectares)
current age class distribution
non-timber harvesting land base
timber harvesting land base
stand age in 10-year classes
age class distribution in 50 years
age class distribution in 100 years
age class distribution in 150 years
age class distribution in 200 years
age class distribution in 250 years

Figure 14. Changes in age composition on the productive land base over time — Mackenzie TSA base case, 2001.

4 Results

The current age class distribution shows that stands within the timber harvesting land base are not evenly distributed with a significant portion (45%) of the stand ages at or greater than 140 years old but less than 5% above 250 years old. The stands with age less than 40 years old make up only 7% of the timber harvest land base.

The same general distribution of age classes applies to the non-timber harvesting land base. Most of those stands are at the age from 130 to 240 years old. A small portion of those stands are less than 40 years old. These younger stands are thought to originate from previous fires and pest activities. Similar to the timber harvesting land base, the non-timber harvesting land base has only less than 5% of the forest greater than 250 years old.

One consequence of the small proportion of stands greater than 250 years is that some of the old-growth requirements for landscape-level biodiversity are not met until the beginning of the fifth decade of the harvest forecast. This lack of older forest of some biogeoclimatic variants in some landscape units does not necessarily mean that merchantable forest cannot be harvested. The forest estate model used by the B.C. Forest Service reserves some of the older forest from the timber harvesting land base which are needed to meet old-growth objectives until stands outside the timber harvesting land base can meet the requirements. A substantial area close to the 250-year threshold can be reserved to meet old-growth requirements. Also, the old-growth threshold of some biogeoclimatic zones is 140 years old. Since 80% of forest on the timber harvesting land base is currently eligible for harvesting, there are sufficient merchantable stands available to meet the harvest forecast during the waiting period. Reserving stands for a long time extends the period over which existing stands are harvested, and results in fluctuations around average volume and area harvested into the long term.

5 Timber Supply Sensitivity Analyses

The best available information on forest inventories and management practices is used to analyse the timber supply implications of continuing with current management. However, forest management is a complicated endeavour that must account for diverse and changing human values, the dynamics of complex ecosystems and fluctuating and uncertain economic factors. As well, forests grow slowly in terms of human time spans, which means that decisions we make today have not only short-term but also long-term effects. Therefore, we cannot be certain that all the data accurately reflect the current state of all values in the forest, how the forest will change or how our management activities will affect the forest.

One important way to deal with this uncertainty is to revise plans and analyses frequently to ensure they incorporate up-to-date information and knowledge. Frequent planning and decision-making can help minimize any negative effects that may occur if decisions are based on inaccurate information. Frequent revision can also ensure that opportunities that become apparent from new information are not missed.

Another important way of dealing with uncertainty is to assess how values of interest, for example, timber supply, could change if the information used in the analysis is inaccurate. Sensitivity analysis is one way of evaluating how uncertainty could affect analysis results and ultimately decision-making. Sensitivity analysis can highlight that fairly small uncertainties about some variables could have large effects on timber supply projections, or conversely that fairly large inaccuracies in others could have negligible effects. Also, sensitivity analysis could show that some variables affect timber supply more in the short term than in the long term, while others have the opposite effect. It can highlight priorities for collecting information for future analyses, and show which variables and associated uncertainties have the most significance for decisions. Sensitivity analysis can clarify whether current best estimates provide a safe basis for decisions, or whether high uncertainty about important variables means more conservative decisions may be wiser.

In this section, results of several sensitivity analyses are discussed. Sensitivity analyses are intended primarily to test the relative change (i.e., high *versus* low sensitivity) in the harvest forecast resulting from changes in forest management assumptions and data used in the base case.

5.1 Uncertainty in the estimated area of timber harvesting land base

Uncertainty in the estimated size of the timber harvesting land base is due to factors such as fluctuations in timber prices, changes in the definition of problem forest types (PFT) and marginal stands, changes in harvesting and milling technology and land-use decisions.

The timber harvesting land base has changed significantly since the last timber supply analysis for the Mackenzie TSA. While the land base was significantly reduced by protected areas and wildland, it has also increased significantly due to the re-assessment of operability. A review of harvest performance also contributed to the delineation the timber harvesting land base. (Ministry of Forests, Mackenzie TSA determination of the timber harvesting land base, April 2001.)

There is reference to the near and far zones of the TSA. The near zone refers to southern portions of TSA which has more developed access, whereas the far zone is the less developed northern portion of the TSA. Development and transportation costs may reduce economic operability of timber in the far zone.

5.1.1 Uncertainty in size of the timber harvesting land base

As previously discussed, the timber harvesting land base has increased from 1.16 to 1.45 million hectares when compared with the 1995 analysis, mostly as a result of operability reclassification. There is uncertainty about both physical and economic operability due in part to the extensive nature of the land base, and to potential changes in future markets and technology. Currently there is no indication that the timber harvesting land base has been over- or underestimated. However, sensitivity analyses was performed to test the impact of modelling the same approximate timber harvesting land base area as previous (a 20% reduction). To accomplish the sensitivity analysis, 20% of the timber harvesting land base was shifted to the area not available for harvesting. The results are shown in Figure 15.

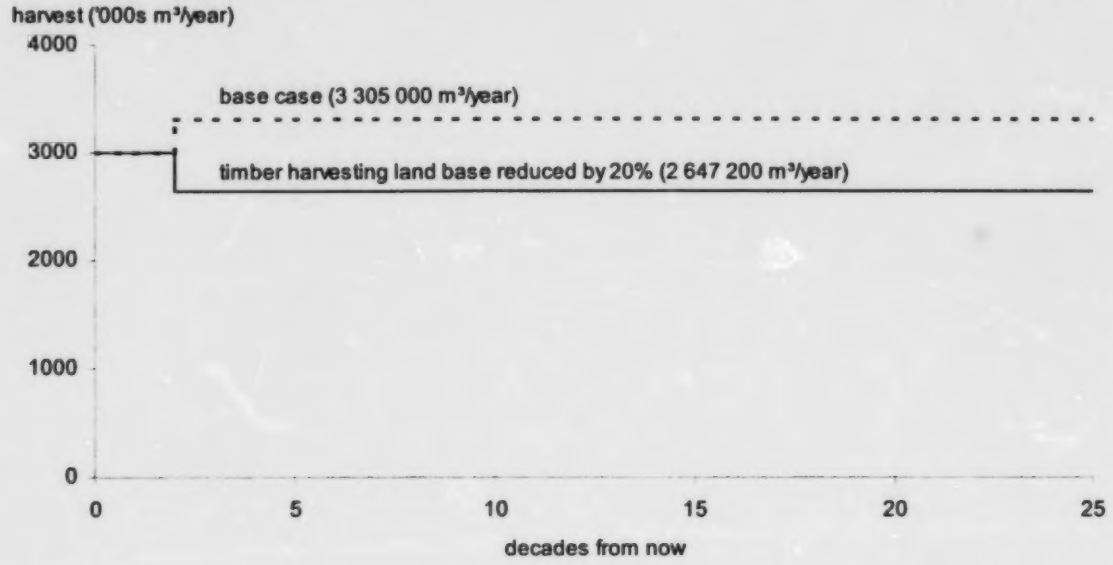

Figure 15. Harvest forecast if timber harvest land base is reduced by 20%— Mackenzie TSA, 2001.

<u>If the timber harvesting land base is 20% smaller than in the base case</u>

- There is still sufficient area in older existing stands to support the base case initial harvest level for two decades.
- After two decades, harvest decreases by 12%.
- The long-term harvest level of 2 647 200 cubic metres per year is reached in decade 3, about 20% below the base case.

5 Timber Supply Sensitivity Analyses

5.1.2 Uncertainty in harvesting the far zone

Access to the far haul zone is uncertain due to its extreme distance and high transportation costs.

Figure 16 shows the impacts of shifting all stands in the far zone out of the timber harvest land base.

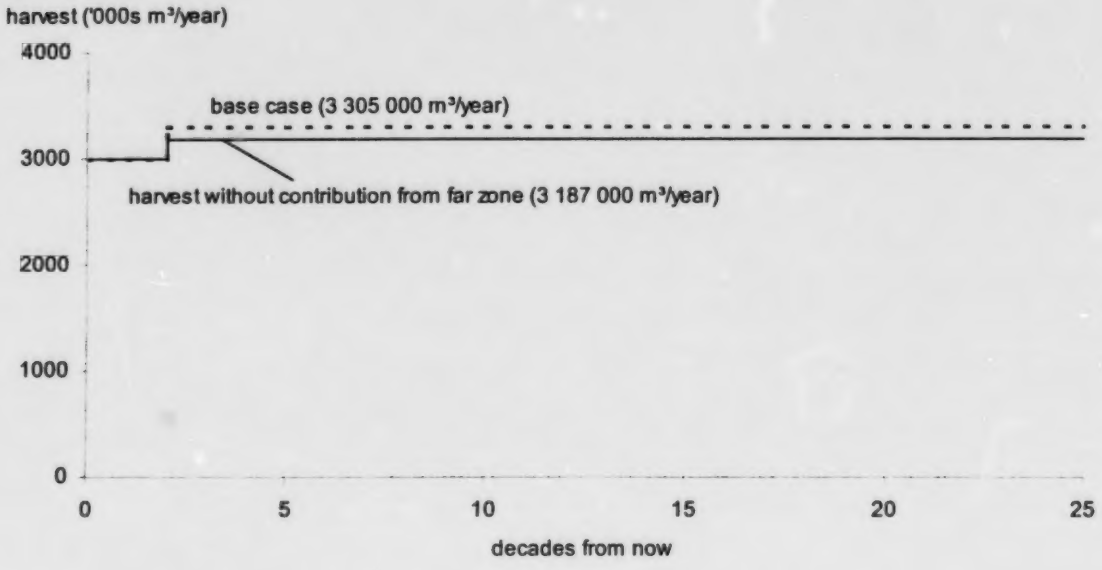

Figure 16. Harvest forecast if the far zone is not included in timber harvesting land base — Mackenzie TSA, 2001.

<u>If the timber harvesting land base is reduced by excluding the far zone area</u>

- The area of timber harvesting land base is reduced by 3.9% from 1 446 398 hectares to 1 390 043 hectares.
- Sufficient area is still available in older existing stands to support the base case initial harvest for two decades.
- After two decades the harvesting level increases by about 6% compared to the current level but 118 000 cubic metres (4%) less than the base case long-term harvest level.
- Long-term harvest level of 3 187 000 cubic metres per year is reached in decade 3.

5 Timber Supply Sensitivity Analyses

5.1.3 Uncertainty in harvesting marginal stands

Marginal stands have lower quality timber and volume. In the base case only near-zone marginal stands are included. Figure17 shows the impact to the base case harvesting if all the marginal stands are either included or excluded.

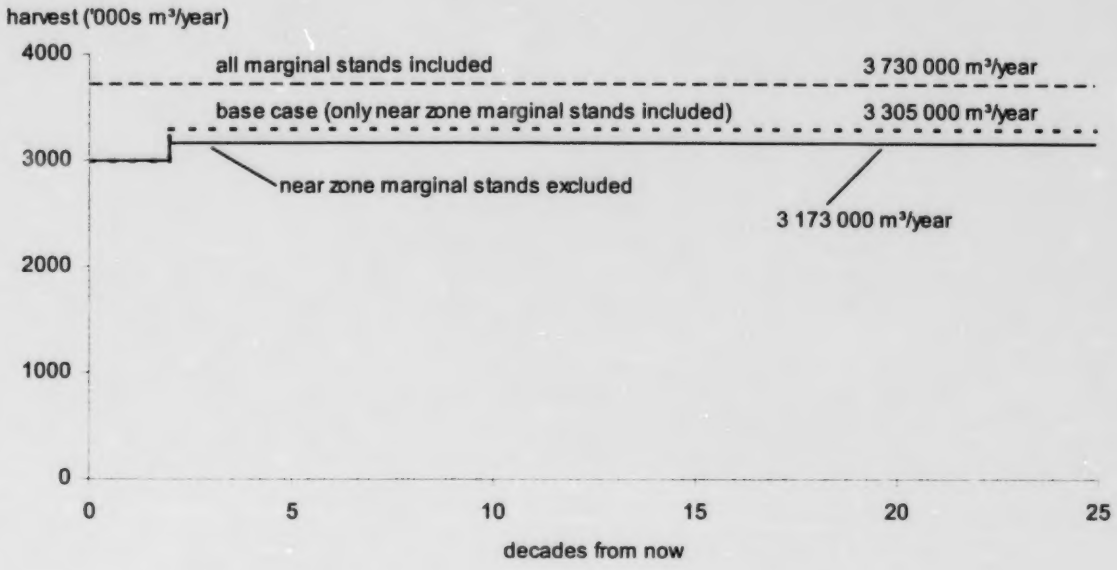

Figure 17. Harvest forecast if marginal stands are excluded or totally included— Mackenzie TSA, 2001.

<u>If the timber harvesting land base is reduced by excluding the near-zone marginal stands</u>

- The area of timber harvesting land base is reduced by 4.2% from 1 446 398 hectares to 1 386 348 hectares.
- Sufficient area is still available in older existing stands to support the base case initial harvest for two decades.
- After two decades harvest is less than the base case by about 4%.
- Long-term harvest level of 3 173 000 cubic metres per year is reached in decade 3.

<u>If all marginal stands are included in the timber harvesting land base</u>

- The area of timber harvest land base is increased by 20.4% from 1 446 398 hectares to 1 741 511 hectares.
- Short-term harvest level increases to approximately 24% higher than the base case.
- Medium- and long-term harvest levels are approximately 12.9% higher than the base case.

5.1.4 Uncertainty in harvesting balsam-leading stands

Balsam-leading stands are not preferred for timber harvesting. Therefore the harvest of balsam stands is more affected by factors such as access and market conditions. Balsam-leading stands totalling 120 872 hectares were included in the base case.

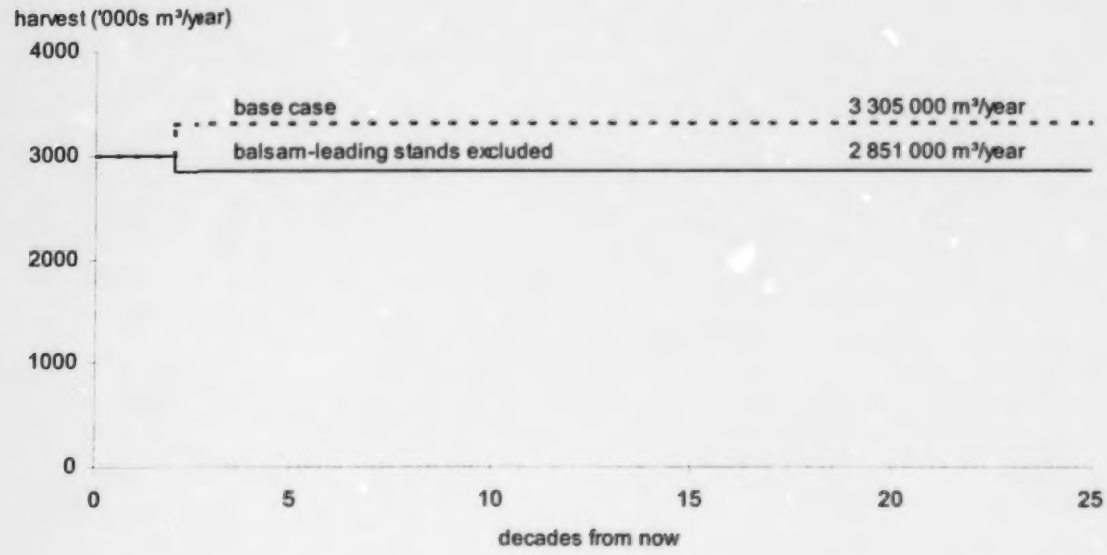

Figure 18. Harvest levels if balsam-leading stands are excluded — Mackenzie TSA, 2001.

<u>If timber harvesting land base is reduced by excluding the balsam-leading stands</u>

- The area of timber harvesting land base is reduced by 8.4% from 1 446 398 hectares to 1 325 527 hectares.
- Sufficient area in older existing stands is still available to support the base case initial harvest for two decades.
- After two decades, the harvest level is less than the base case by about 13.7%.
- Long-term harvest level of 2 851 000 cubic metres per year is reached in decade 3, a decrease of 4.9% from the initial harvest level.

5.1.5 Uncertainty in harvesting deciduous-leading stands

Like the balsam-leading stands, the harvesting of deciduous-leading stands depends on factors such as access and market conditions. The forest district has a plan to sell 50 000 cubic metres of deciduous timber each year from the near-zone south portion of Peace Arm. If the deciduous-leading stands in the near-zone north of Peace Arm are included, the timber harvesting land base is increased by about 471 hectares. The impact on timber supply is negligible. Figure 19 shows the impact of including all deciduous-leading stands in the TSA.

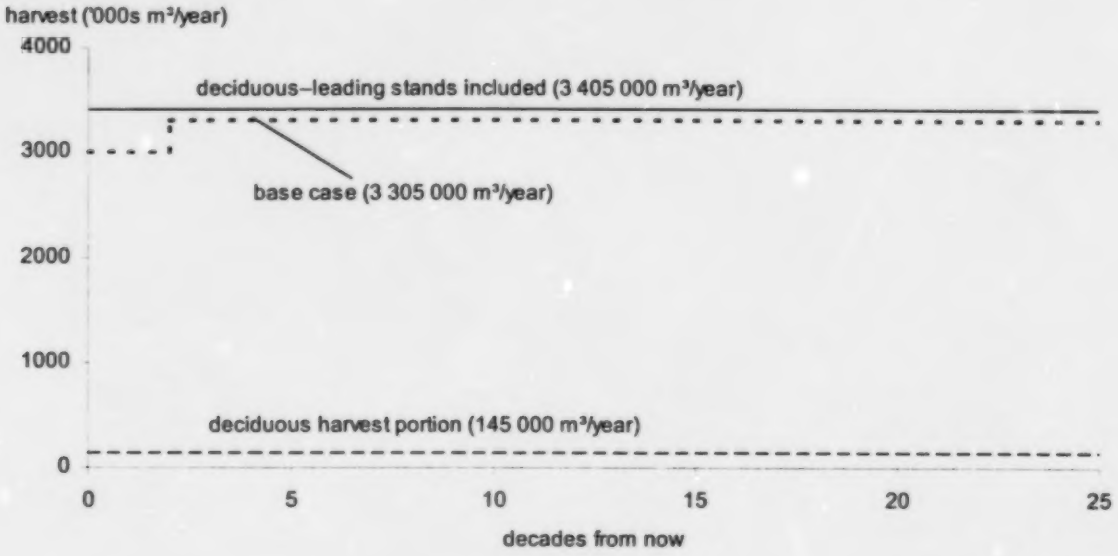

Figure 19. Harvest level if all deciduous-leading stands are included— Mackenzie TSA, 2001.

For the sensitivity analysis to show the impact of deciduous-leading stands on timber supply, the target of 50 000 cubic metres partition for deciduous-leading stands was increased.

<u>If the timber harvesting land base is increased by including all deciduous-leading stands</u>

- The area of timber harvest land base would increase by 3.3% from 1 446 398 hectares to 1 494 353 hectares.
- The short-term harvest level is approximately 14% higher than the base case.
- The medium-term and long-term harvest levels are approximately 3% higher than the base case harvest level.
- The partition of deciduous in the base case is 50 000 cubic metres (the maximum level that could be harvested is 90 000 cubic metres in the base case). The maximum level that could be harvested for all deciduous-leading stands is 145 000 cubic metres per year.
- If the demand for deciduous exceeds 145 000 cubic metres another approximately 8000 hectares of deciduous-leading stands with stocking class 2 is available for harvesting.

5.2 Uncertainty in estimated time to green-up

Forest cover requirements* for visual quality, wildlife habitat, water quality and adjacency applied in this analysis involve estimates of when stands will reach green-up conditions, expressed as the desired height of a stand (see Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis" for desired green-up heights for each management emphasis area). Green-up age, the age at which a stand reaches the required height, was determined for the Mackenzie TSA by examining the height growth of regenerating stands in the forest district. Green-up tables for the forest regions of British Columbia are provided in *Age to green-up: using regeneration survey data* (Pollack et al. 2000).

The green-up period includes both the green-up age and the regeneration delay, or time taken to establish a stand after harvesting. Uncertainty about green-up period arises because the desired green-up condition (that is, tree height) may either exceed or fall short of actual needs, the period of stand establishment may vary, and variations in local stand growth from the regional average may result in stands reaching the desired condition sooner or later than estimated. In the Mackenzie TSA, the green-up constraints only apply to the visual scenic areas. For all other areas the constraints from the *Landscape Unit Planning Guidebook* were applied.

Sensitivity analysis shows that timber supply is not sensitive to a 5-year increase or decrease in the time to green-up.

Forest cover requirements
Specify desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest cover objectives (see Green–up).

5.3 Uncertainty in estimated existing stand yields

Timber volume estimates for existing unmanaged stands are subject to uncertainties in the forest inventory used to estimate timber volumes (i.e., estimated tree heights and stand ages), and the statistical process used to develop the equations for predicting forest growth and yield. In 1996, the Ministry of Forests audited the Mackenzie TSA inventory. The audit results suggested that over the entire TSA, actual timber volumes in mature forests were on average 10% lower than estimated by the inventory. Since that time, a portion of the TSA has been re-inventoried. Preliminary analysis suggests that the existing inventory may overestimate volumes by more than 10%; however, more detailed assessment is needed to verify the results. A sensitivity analysis was performed to test the potential effect on timber supply of uncertainty in the estimates of the existing unmanaged stand volumes. The results of increasing existing unmanaged stand yield estimates by 10% and decreasing them by 10% or 20% are presented in Figure 20.

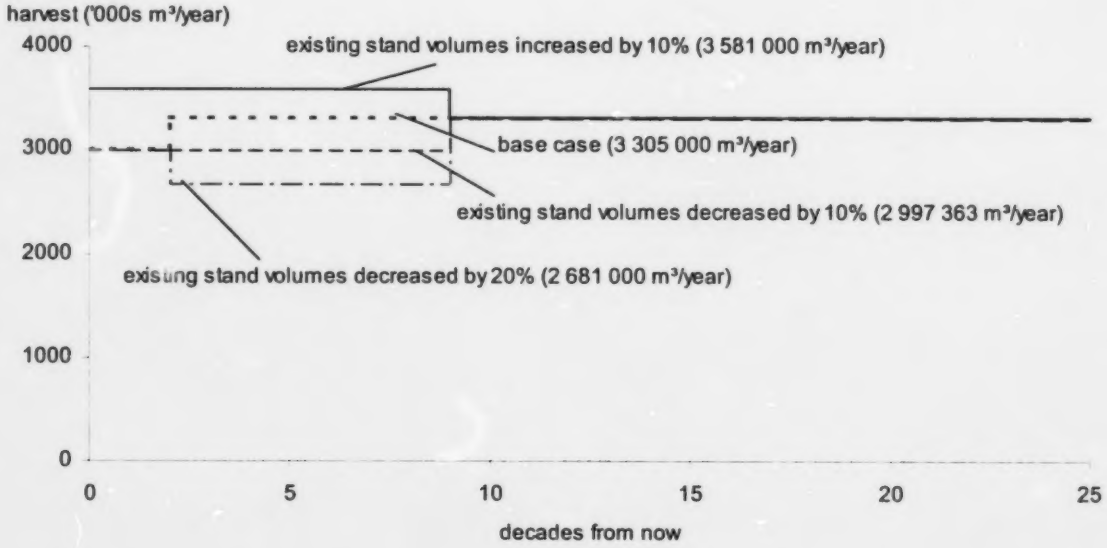

Figure 20. Harvest forecast if volume estimates for existing unmanaged stands increase by 10% or decrease by 10% or 20%— Mackenzie TSA, 2001.

<u>If existing unmanaged stand volumes are 10% higher than in base case</u>

- A harvest level of 3 581 000 cubic metres per year can be maintained for nine decades.
- The long-term harvest level is reached at decade nine.

<u>If existing unmanaged stand volumes are 10% lower than in base case</u>

- Sufficient area still exists in older existing stands to support the current harvest for nine decades.
- The medium-term harvest forecast would be about 11% less than the base case.
- The long-term harvest level is reached at decade 9.

<u>If existing unmanaged stand volumes are 20% lower than in base case</u>

- Sufficient area still exists in older existing stands to support the current AAC harvest for two decades.
- The medium-term harvest forecast would be 10.5% lower than current AAC.
- The long-term harvest level is reached at decade nine.

5 Timber Supply Sensitivity Analyses

5.4 Uncertainty in estimated managed stand yields

Uncertainty in volume estimates for managed stands exists for the same reasons listed for estimated existing stand yields (inaccuracies in the forest inventory and the growth and yield models), but also because of the limited experience and data that are available for regenerated managed stands in British Columbia. (There is also uncertainty around the site productivity assigned to older unmanaged stands relative to the site productivity expressed by the stands after they regenerate. This issue is examined in Section 5.5, "Uncertainty in productivity of current old-growth sites after harvest"). Figure 21 shows the harvest forecast results when regenerated stand volumes are increased and decreased by 10%.

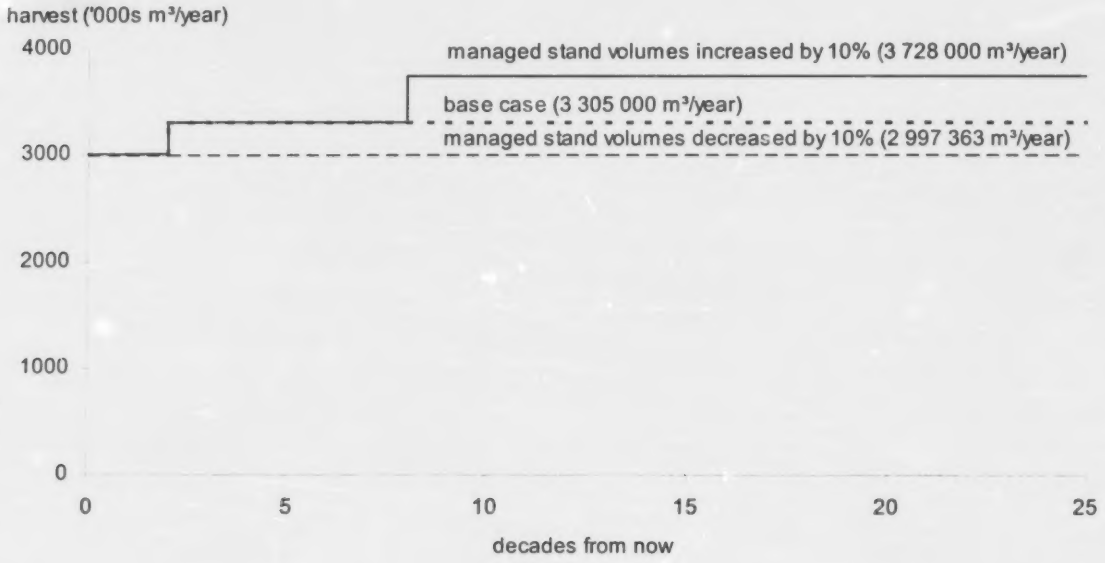

Figure 21. Harvest forecast if volume estimates for managed stands increase or decrease by 10%—Mackenzie TSA, 2001.

When regenerated stand yields are decreased by 10%

- Harvest level would be maintained at current AAC for the whole planning horizon.
- Long-term level is 12% below the base case long-term level.

When regenerated stand yields are increased by 10%

- Long-term harvest level increased to 3 728 000 cubic metres per year, 12.8% greater than the base case, beginning in decade 9.

Changes to regenerated stand yields have no effect on the short-term harvest forecast for the Mackenzie TSA. Regenerated stands are not eligible for harvest until they have reached their minimum harvestable ages, which range between 45 and 260 years. While some young existing managed stands will achieve their minimum harvestable ages beginning in a few decades, the timber inventory in the TSA is dominated by older existing stands. The harvest is projected to shift to regenerated stands starting in 100 years from now (see Section 4.1.1, "Base case timber supply dynamics").

5 Timber Supply Sensitivity Analyses

5.5 Uncertainty in productivity of current old-growth sites after harvest

The productivity of a site largely determines how quickly trees will grow. It therefore affects the timber volumes in regenerated stands, the time to reach green-up and the age at which stands will reach merchantable size. The most accurate estimates of site productivity come from stands between 30 and 150 years old. At ages less than about 30 years a temporary increase or decrease in growth due to factors such as a post-harvest flush of nutrients or an unusual drought year can affect the overall productivity estimated for the stand. At older ages, site productivity estimates may be incorrect because tree heights do not represent actual production — for example due to top breakage — and it is very difficult to determine ages of old trees accurately. The results of recent province-wide research suggest that the estimated productivity of sites currently occupied by old-growth stands may be significantly underestimated. Two Old Growth Site Index (OGSI) studies applicable to timber supply forecasting are:

- *Site index adjustments for old-growth stands based on paired plots* (Nussbaum 1998). Data were obtained from paired plots installed in old-growth stands and adjacent logged and regenerated stands of the same productivity. Site index* was estimated for both and compared. Results are available for Douglas-fir, lodgepole pine and interior spruce.
- *Site index adjustments for old-growth stands based on veteran trees* (Nigh 1998). The objective of the study was to develop site index adjustments for species not covered by the paired-plot project. The data for this study came from temporary and permanent plots with a veteran and main stand component. The site indices for the two components were estimated and an adjustment equation for each species was derived using linear regression analysis. The results of the study are considered less reliable than those from the paired-plot study.

The results of these studies are of interest in the Mackenzie TSA since stands older than 140 years comprise 37% of the timber harvesting land base. To test the sensitivity of the base case harvest forecast to uncertainty about site productivity estimates, an analysis was performed that incorporated adjustments to site indices.

OGSI adjustments

Site indices of stands older than 140 years were adjusted using either the paired-plot or veteran-tree results, whichever was applicable. Managed stand volume estimates for those analysis units* affected by changes in estimated future productivity were recalculated based on average adjusted site productivity. Green-up and minimum harvestable ages were also recalculated. Table 3 compares the average forest inventory-based site index for each tree species group to those defined using each of the adjustments.

Site index
A measure of site productivity. The indices are reported as the average height, in metres, that the tallest trees in a stand are expected to achieve at 50 years (age is measured at 1.3 metres above the ground). Site index curves have been developed for British Columbia's major commercial tree species.

Analysis unit
A grouping of types of forest — for example, by species, site productivity, silvicultural treatment, age, and or location — done to simplify analysis and generation of timber yield tables.

5 Timber Supply Sensitivity Analyses

Table 3. Average analysis unit site index based on forest inventory and OGSI adjusted information — Mackenzie TSA, 2001

Analysis unit	Area (hectares)	Inventory site index	Adjusted site index
Pine/spruce good	5 898	14.9	16.6
Pine/spruce medium	60 104	11.2	15.1
Pine/spruce poor	69 000	9.0	13.9
Spruce good	22 684	18.4	20.9
Spruce medium	139 366	13.1	19.9
Spruce poor	118 014	7.9	19.0
Pine good	21 685	19.1	20.9
Pine medium	37 890	15.5	20.3
Pine poor	41 972	12.4	19.8

The average site index for the entire Mackenzie TSA increased from 14.0 to 16.5 with OGSI adjustments.

If the managed stands volumes are adjusted for OGSI adjustments (Figure 22)

- Harvest forecast is the same as the base case for the first eight decades.
- Long-term harvest level of 4 100 000 cubic metres per year — 24% above base case — can be maintained from decade 8 onward.

5 Timber Supply Sensitivity Analyses

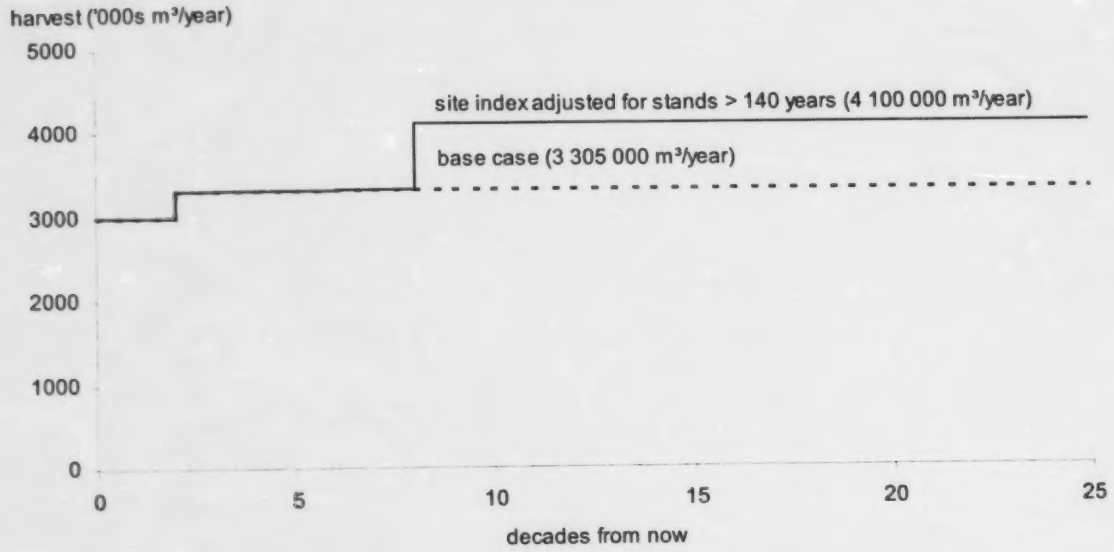

Figure 22. Harvest forecast based on OGSI (veteran studies) site index adjustments — Mackenzie TSA, 2001.

5.6 Uncertainty in green-up requirements

In the Mackenzie TSA, approximately 4% of the timber harvesting land base area is determined to be visually sensitive to timber harvesting. Where visual quality objectives apply, limits are placed on the percentage of the area where harvesting-related disturbance may be visible (allowable disturbance percentages). When newly established forest reaches a specified height, the disturbance is no longer visible (visually effective green-up). Uncertainties are associated with both the allowable disturbance percentages and achievement of visually effective green-up.

Percentage limits on visible disturbance

The level of harvest from visually sensitive areas is a function of the visual absorption capacity, the visual quality rating, and the current visual condition of each area. Uncertainty about forest cover and green-up objectives for visual quality may arise from inventory and classification of land into visual absorption capacity classes, from estimates of how well different disturbance limits may meet visual objectives, and from estimates of how non-harvestable forest may contribute to visual quality. At the time of the analysis, the constraint levels were under discussion at the LRMP table.

In the base case, the mid-point of the applicable range of allowable visible disturbance was applied to each visual management polygon. Sensitivity analyses were performed to assess the impacts of relaxing and increasing forest cover constraints for visual quality.

Since visually sensitive area is small (4%) relative to the timber harvesting land base, the sensitivity analysis shows that either relaxing the forest cover constraints to the maximum level or decreasing the allowable disturbance in visual areas to the minimum of the range does not impact the base case forecast harvest level. The same applies to VQO disturbance requirements in the LRMP.

Maximum disturbance for other areas

In the base case there is no special requirement for the timber harvest land base outside VQO areas. Constraints from the *Landscape Unit Planning Guidebook* were applied to those areas outside VQO areas. A sensitivity analysis was performed to try to find the impact on the base case harvest level if disturbance rates were reduced. As shown in Figure 23, the maximum disturbance for areas outside of VQO areas would not affect harvest levels until reduced below 14%.

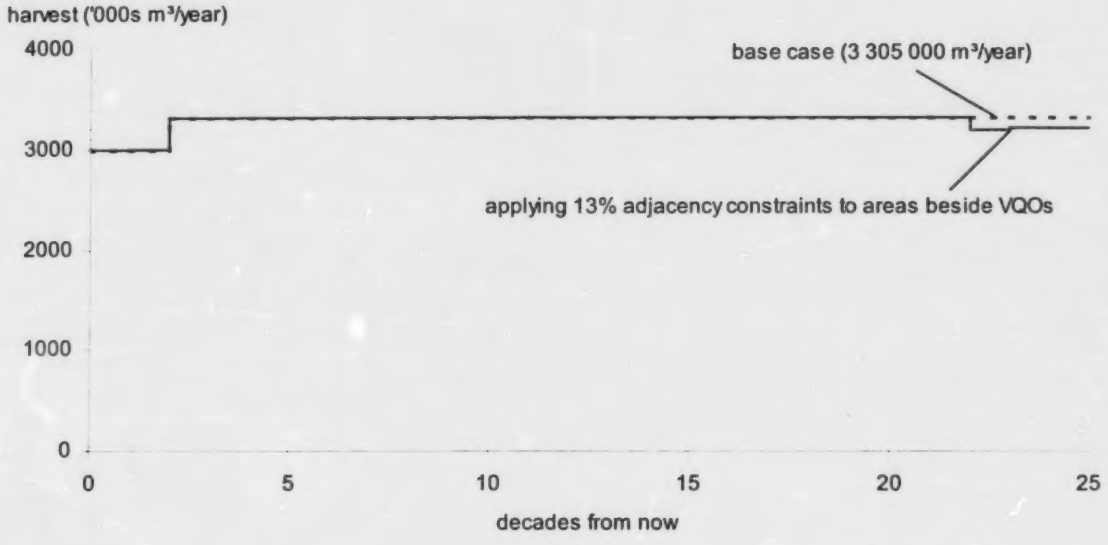

Figure 23. Harvest levels if disturbance rates reduced to 13% (outside of VQO areas) — Mackenzie TSA, 2001.

<u>If the allowable disturbance (excluding VQO areas) is reduced to 13%</u>

- Harvest forecast maintains the same as the base case until decade 20 at which time it is reduced to 3 192 000 cubic metres per year.
- Harvest levels remain the same as the base case if allowable disturbance rates are reduced to 14% (for areas outside VQO areas).

5 Timber Supply Sensitivity Analyses

5.7 Uncertainty in estimated minimum harvestable ages

Minimum harvestable age is an estimate of the time needed for a stand to reach a merchantable condition. The time at which stands will become merchantable is highly uncertain. This is partly because of uncertainty about the growth of regenerated stands, but more importantly because future conditions that will determine merchantability cannot be foreseen. For this analysis, minimum harvestable ages were estimated based on the criteria in Table 4.

Table 4. Minimum harvestable age criteria

Species	Haul zone	Logging system	Volume
Spruce	Near	Conventional	140
		Conventional/cable	180
		Cable	220
	Far	Conventional	180
		Conventional/cable	220
		Cable	250
Pine	Near	Conventional	140
		Conventional/cable	180
		Cable	220
	Far	Conventional	160
		Conventional/cable	220
		Cable	250
Balsam	Near	Conventional	140
		Conventional/cable	180
		Cable	220
	Far	Conventional	180
		Conventional/cable	220
		Cable	250

The minimum harvestable age of deciduous-leading stands was set at 60 years by the forest district. These minimum stand volume criteria are described in detail in Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis," and apply to both managed and unmanaged stands. These criteria were chosen to ensure that only stands with sufficient merchantable volume would be considered available for harvest. The minimum harvestable ages are minimums; in this analysis stands may be harvested at older, but not younger, ages. In fact, many stands are harvested at ages beyond the minimum to meet management objectives and forest cover requirements. Minimum harvestable ages are meant to approximate the timing of merchantability, and are not legal or policy requirements.

For the Mackenzie TSA 80% of the stands are above the minimum harvestable age. The area-weighted average minimum harvestable age for the whole TSA is 90 years old and the area-weighted average culmination age* is 120 years old. The projected harvest age for the planning horizon is generally above the culmination age (age at which maximum harvest flow can be achieved). Therefore, increasing or decreasing the minimum harvestable age by 10 years does not have an impact on the base case harvest level.

Culmination age
The age at which a timber stand reaches its highest average growth rate, or mean annual increment (MAI). MAI is calculated as stand volume divided by stand age. Culmination age is the optimal biological rotation age to maximize long-term volume production from a growing site.

In this analysis, minimum harvestable ages are not viewed as decisions made to meet forest management objectives, but rather as approximations of the timing of merchantability. This analysis highlights that timber supply is not sensitive to some degree of uncertainty about this timing (plus or minus 10 years). Whether minimum harvestable ages used in the base case are appropriate, optimistic or pessimistic is largely a matter of opinion. These issues are discussed here because, of all variables important to timber supply, minimum harvestable ages are perhaps the most uncertain, at least in areas where most second growth will not be harvested for many years. Many other variables are based on sampling data and experience, or management decisions. Minimum harvestable age, however, will depend on technology and markets well into the future.

5.8 Uncertainty in the application of provincial average biodiversity requirements

As described in Appendix A, "Description of Data Inputs and Assumptions for the Timber Supply Analysis," prescriptions for maintaining biodiversity at both the stand level and the landscape level were modelled in the base case. Stand-level biodiversity was addressed in this analysis by removing portions of each stand from the timber harvesting land base. Uncertainty about stand-level biodiversity can be assessed through sensitivity analysis that examines the timber supply impacts of land base reductions. Landscape-level biodiversity, however, was modelled in this analysis through the use of forest cover requirements applied to biogeoclimatic variants within each landscape unit.

Management for landscape-level biodiversity in the Mackenzie TSA includes provision for the maintenance of young and mature forest as well as old-growth forest through patch size management. The base case included the requirements for mature forest, old forest and young forest from the *Landscape Unit Planning Guidebook*. The program cannot model patch size. There is uncertainty about how the recommendations in the *Landscape Unit Planning Guidebook* should be interpreted and the land base to which they are applied.

A sensitivity analysis shows that application of the provincial average biodiversity requirements (45/45/10) does not affect the base case harvest level.

5.9 Uncertainty in the application of the land and resource management plan (LRMP) biodiversity requirements

The Mackenzie Land and Resource Management Plan (LRMP) was not complete at the time of this analysis. The requirements for biodiversity in the LRMP differ from that in the base case. In the LRMP, the special resource management zone was assigned to high emphasis, general resource management zone to intermediate emphasis, and the enhanced resource management zone to low emphasis. Sensitivity analysis shows that applying the LRMP emphases does not affect the base case harvest level.

5 Timber Supply Sensitivity Analyses

5.10 Uncertainty in including the deciduous portion of conifer-leading stands

In the base case, the deciduous portions were excluded from the coniferous yield table. The forest district suggests that those deciduous portions could be used under appropriate market conditions. Separate coniferous yield tables were generated to estimate the deciduous portion and a sensitivity analysis was performed, as shown in Figure 24.

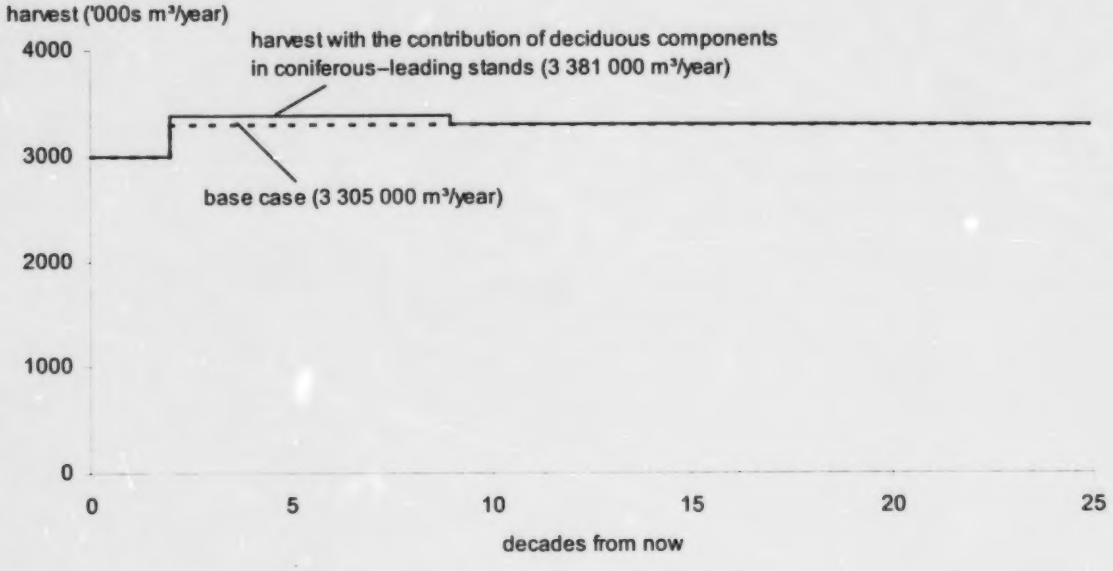

Figure 24. Harvest level if deciduous components of coniferous-leading stands are included— Mackenzie TSA, 2001.

Including the deciduous components in conifer-leading stands

- The medium-term harvest level could be increased in decade 3 by 3% to 3 381 000 cubic metres per year and maintained at that level until decade 9.
- The long-term harvest level is the same as the base case since all conifer-leading stands are expected to regenerate to pure conifer stands.

5 Timber Supply Sensitivity Analyses

5.11 Uncertainty in managing coniferous components of deciduous-leading stands

Where conifers comprise at least 40% of the deciduous-leading stands, there is a possibility to convert those deciduous-leading stands to conifer stands after harvest. In the base case those stands are treated as natural regenerated stands and returned to the same deciduous stand yield table. Sensitivity analysis shows the result if those stands regenerated to managed conifer stands.

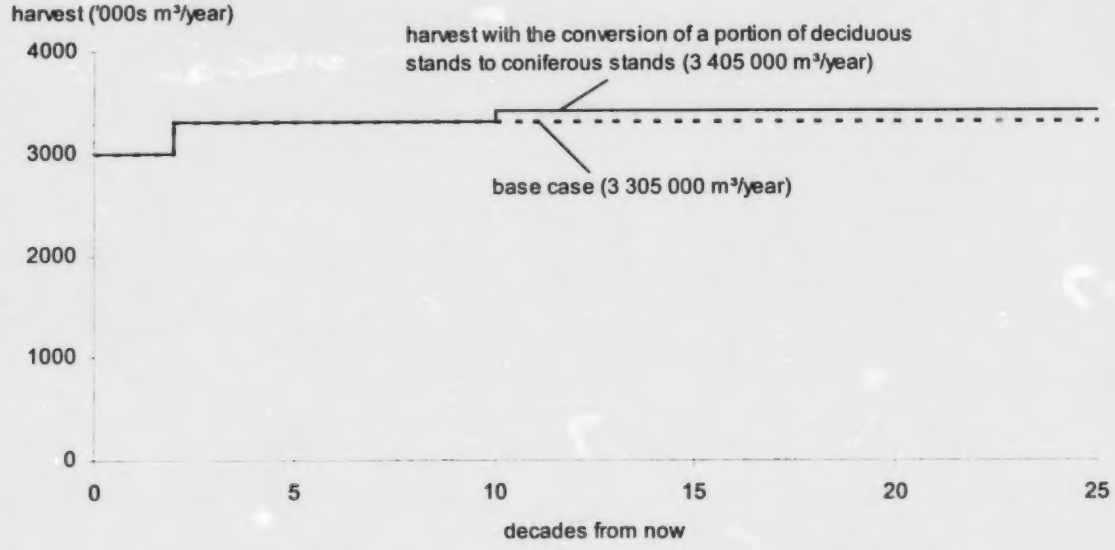

Figure 25. Harvest level if deciduous stands with significant conifer portion regenerate to coniferous stands — Mackenzie TSA, 2001.

Converting the higher conifer component deciduous-leading stands to pure conifer stands after harvest

- Initial harvest level would not be changed.
- The harvest level would be increased to 3 405 000 cubic metres per year at decade 10.
- The long-term harvest level is 3% higher than in the base case.

5 Timber Supply Sensitivity Analyses

5.12 Uncertainty in the application of wildlife management requirements from the land and resource management plan (LRMP)

The requirements for wildlife management in the LRMP were not finalized at the time of the analysis, and therefore not included in the base case.

The requirements for caribou habitat management for the Morfee and Misinchinka landscape units allow a maximum of 33% of the area to be less than 80 years old. Sensitivity analysis shows that applying the constraints for caribou habitat management in those two landscape units does not affect the base case harvest level.

The requirement for higher value caribou habitat is to allow a maximum of 5% of the area to be less than 10 years old. Sensitivity analysis shows that applying caribou habitat management does not affect the base case harvest level.

The requirements for grizzly bear habitat management are: in areas of spring habitat, assume all harvested stands are generated to natural stands by using the VDYP natural stand growth model (rather than TIPSY managed stand growth model) with a regeneration delay of five years. Figure 26 shows the result.

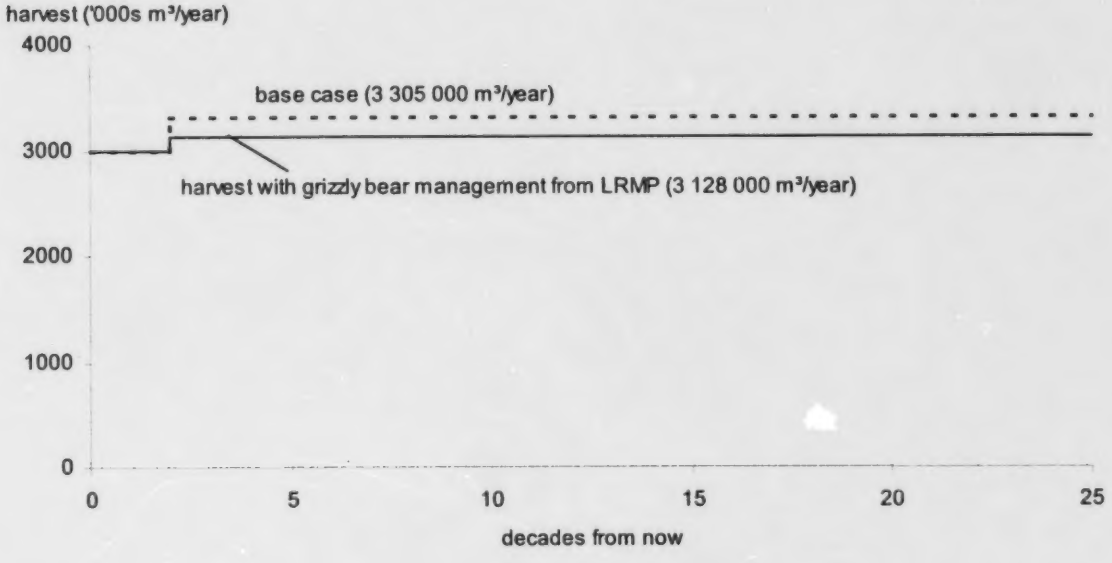

Figure 26. Harvest level if grizzly bear habitat management from LRMP implemented— Mackenzie TSA, 2001.

Applying management for grizzly bear habitat from the LRMP:

- Initial harvest level would not be changed.
- The harvest level would increase to 3 128 000 cubic metres per year at decade 3.
- Long-term harvest level is 5.4% lower than that in the base case.

5 Timber Supply Sensitivity Analyses

5.13 Alternative harvest queue rules

In the base case, the highest priority for harvest is given to stands that were the oldest relative to their minimum harvestable age. This "relative oldest first" rule is applied only after other requirements and priorities (e.g., forest cover requirements) are taken into account. This rule reflects the practice of favouring older stands for harvest, but not necessarily the oldest, when all other considerations have been met.

Besides the relative oldest first rule, the Forest Service Simulator (FSSIM) model can also employ absolute oldest first, random and youngest first scheduling rules. These other harvest rules may better reflect practices in some instances, given unforeseeable operational constraints that may affect when stands are chosen for harvest. Sensitivity analysis has shown that timber supply is not affected by applying the oldest first and random scheduling rules. Although there is sensitivity to harvesting youngest stands first, this does not reflect any foreseeable management practices or operational constraints.

5.14 Summary of sensitivity analyses

Table 5 summarizes all sensitivity analyses. Sensitivity analyses showing an increase relative to the base case harvest forecast are presented first, followed by those showing a decrease. Sensitivity analyses showing no impact relative to the base case are presented last.

5 Timber Supply Sensitivity Analyses

Table 5. Summary of sensitivity analysis — Mackenzie TSA, 2001

Report section	Description	Impact of sensitivity analysis relative to the base case		
		Short term	Medium term	Long term
5.1.3	Include all marginal stands	+	+	+
5.1.5	Include all deciduous-leading stands	+	+	+
5.4	Increase managed stand yields		+	+
5.5	Include Old-growth site index adjustments		+	+
5.3	Increase existing stand yields	+	+	
5.10	Include deciduous components		+	
5.11	Include stands conversion			+
5.1.1	Reduce timber harvesting land base		–	–
5.3	Reduce existing stand yields		–	
5.4	Reduce managed stand yields		–	–
5.1.2	Exclude far zone area		–	–
5.1.3	Exclude near zone marginal stands		–	–
5.1.4	Exclude balsam-leading stands		–	–
5.12	Apply grizzly bear habitat constraints		–	–
5.13	Apply youngest first harvest priority		–	–
5.6	Applying 13% allowable disturbance			–
5.7	Reduce minimum harvestable age			
5.6	Reduce allowable visual disturbance			
5.2	Increase green-up in visual areas			
5.7	Increase minimum harvestable age			
5.2	Reduce green-up in visual areas			
5.2	Increase allowable visual disturbance			
5.8	Apply average BEO (45/45/10)			
5.9	Apply LRMP BEO			
5.2	Increase green-up ages			
5.2	Reduce green-up ages			
5.13	Apply oldest first or random harvest priority			

6 Summary and Conclusions of the Timber Supply Analysis

Using current inventory and timber growth information and assuming continuation of current forest management practices, the results of this timber supply analysis suggest that the current allowable harvest level of 2 997 363 cubic metres per year in the Mackenzie TSA could be maintained for two decades. The results also indicate that in the third decade, the harvest level could increase to 3 305 000 cubic metres per year for the remainder of the analysis period (250 years). Analysis of alternative harvest flows indicates that the long-term harvest level of 3 305 000 cubic metres per year could be achieved in the short term and that a level of 3 596 383 cubic metres per year could be maintained for the first five decades, both without compromising the long-term harvest level.

The base case results reflect current knowledge and information on forest inventory, growth and management. However, uncertainty exists about several factors important in defining timber supply. A series of sensitivity analyses showed that these uncertainties affect timber supply to varying degrees.

Short-term (the next 20 years) timber supply is most sensitive to changes in the extent of the timber harvesting land base. The largest sensitivity would be including marginal stands which would increase the timber harvesting land base by 20.4% and the short-term harvest by 24%. The second-leading sensitivity would be including all deciduous-leading stands which would increase the timber harvesting land base by 3.3% and the harvest by 14% in the short term.

Medium-term (21 to 80 years from now) timber supply is affected by estimates of timber volume in existing stands, the size of the timber harvesting land base and the factors mentioned above that affect short-term timber supply. The largest potential negative effect result from potential reductions in estimates of timber volume in existing stands as indicated in a previous inventory audit. The effect in the medium term could be a reduction in available harvest of 11% or more. The size of the timber harvesting land base was significantly increased when compared with the 1995 timber supply analysis. If a similar size timber harvesting land base is applied as in 1995, both the timber harvesting land base and the medium-term harvest level would be 20% lower. If the harvest from balsam-leading stands (8.4% of the timber harvesting land base) were limited, the medium-term harvest level would be decreased by 4.9% compared to the current harvest level. If marginal stands (4.5% of the timber harvesting land base) are not harvested, the medium- and long-term harvest levels would be 4% lower than in the base case. On the other hand if the far-zone marginal stands are harvested, the medium- and long-term harvest levels in the base case could be increased by about 13%. If the access to the far zone (4% of the timber harvest land base) were not available, the medium-term harvest level would be about 4% lower than in the base case. If grizzly bear management practices from the Mackenzie LRMP are applied, the medium-term harvest level would be 5% lower than the base case harvest level.

Long-term timber supply is affected by uncertainties in estimates of regenerated stand yields, estimates of site productivity for old-growth stands, management of deciduous-leading stands, as well as all factors with large potential effects on short- and medium-term timber supply mentioned previously (except for existing stand yield estimates). If site productivity were to increase to the level indicated in recent provincial research, the long-term harvest level could be increased by 24%.

In conclusion, this analysis indicated that based on current inventory and growth and yield information, and the current management regime, short-term timber harvests in the Mackenzie TSA could be maintained at the current harvest level. A higher medium-term and long-term harvest level could be maintained for the 250-year planning horizon. The analysis indicates that several factors related to the current forest inventory and management regime could affect timber supply. The factors most likely to affect the timber supply projected in the base case are the uncertainty associated with the inventory of existing stands, operability class, harvest of balsam-leading stands, harvest in the far-haul zone, harvest of marginal stands, and the likelihood that site index estimates for old-growth stands underestimates actual productivity for regenerating stands. Other factors show no conclusive evidence to suggest that uncertainty of information used in this analysis would have significant effects on timber supply.

7 Socio-Economic Analysis

The impact of timber supply adjustments on local communities and the provincial economy is an important consideration in the timber supply review. The socio-economic analysis compares the level of forestry activity currently supported by timber harvested from the Mackenzie TSA to the level of activity that the TSA could support as the timber supply moves towards its long-term harvest level.

The socio-economic analysis examines harvest levels as projected in the base case harvest forecast and is not intended to examine alternative management scenarios.

The socio-economic analysis consists of the following:

- a profile of the current socio-economic setting;
- a description of the Mackenzie TSA forest industry; and
- an analysis of the socio-economic implications of the base case harvest forecast.

7.1 Current socio-economic setting

7.1.1 Current population and demographic trends

In 2000, the population of the Mackenzie TSA was approximately 6,490 people.[1] From 1996 to 2000, the population increased marginally. The largest community in the Mackenzie TSA is Mackenzie with an estimated population in 2000 of 6,275 people. Other smaller communities located in the TSA include Manson Creek, Germansen Landing, Tsay Keh Dene and Fort Ware. The population of the TSA is likely to remain relatively stable between 2000 and 2005. Table 6 shows the population levels for the Mackenzie TSA and for communities where data are available.

Table 6. Mackenzie TSA population statistics, 1991–2000

	1991	1996	2000	% change 1991 to 2000
Mackenzie	5,970	6,270	6,275	5.1
Mackenzie TSA	6,300	6,486	6,490	3.0
British Columbia	3,282,910	3,882,043	4,023,100	22.5

Source: Census of Canada 1991, 1996.
B.C. Stats, Population Section. B.C. Ministry of Finance and Corporate Relations.

(1) B.C. Stats, Population Section, B.C. Ministry of Finance and Corporate Relations.

7 Socio-Economic Analysis

7.1.2 Economic profile

From 1991 to 1996, the total experienced labour force in the Mackenzie TSA increased by 6.2% to 3,535 from 3,330.[2] In comparison, the provincial experienced labour force increased by 14% over the same period. The unemployment rate in the Mackenzie TSA was 10.4% in 1996 compared with 12.3% in 1991. Given the stable population it is likely that the labour force has also remained the same. Figure 27 shows the experienced labour force by sector in 1996 for the Mackenzie TSA.

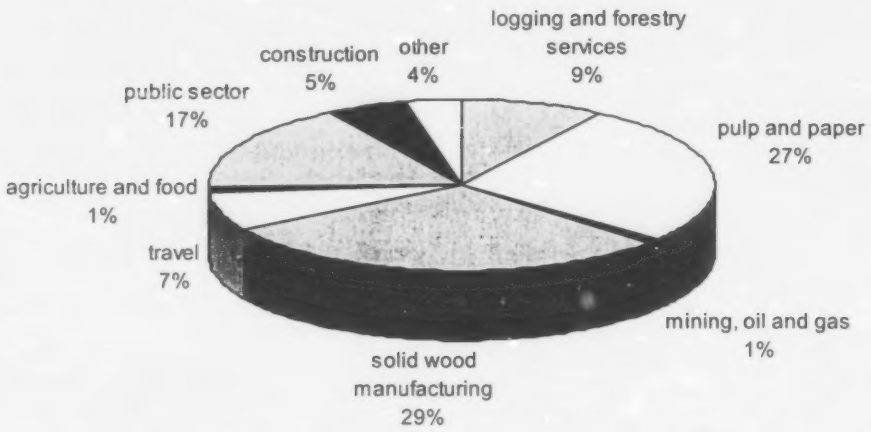

Figure 27. Mackenzie TSA experienced labour force by sector, 1996.

Source: B.C. Ministry of Finance and Corporate Relations, Victoria, B.C. 1999. *The 1996 forest district tables.*

The forest sector is by far the leading employer in the forest district. Statistics from 1996 indicate that the forest sector, which includes harvesting, silviculture and forest products manufacturing, supported about 65% of the total (direct, indirect and induced) labour force. This should come as no surprise since the town was built in 1965 for workers at local sawmills operated by B.C. Forest Products and Cattermole Timber Co. The forest industry is also the dominant source of income for the TSA accounting for 71% of the income flowing into and within the forest district. The Mackenzie TSA has the highest dependence on the forest industry among all provincial forest districts.

(2) Census of Canada, 1991, 1996.

7 Socio-Economic Analysis

Census data indicate that overall forest sector employment increased from 1986 to 1996. However, the positive trend is due to the increase in processing employment, which was larger than a concurrent reduction in harvesting employment. Forest sector employment peaked in the mid-1990s, before declining in both the harvesting and processing sub-sectors.

The public sector, the second largest employer in the Mackenzie TSA, includes municipal, provincial and federal government employment, and education and health. In 1996, this sector supported 17% of the total labour force and 12% of the total income. In comparison, the public sector accounts for an average of 23% of employment in forest districts across the province. Public sector employment in the Mackenzie TSA increased by 62% from 1986 to 1996, with the largest increases occurring in health services employment.

The travel sector in Figure 27 includes both business and tourism travel but is likely dominated by business travel. This sector supports 7% of the total labour force and approximately 3% of the total income flowing within the region. This difference between the percentage employed and the income indicates the below-average wages earned by the average travel sector worker in relation to the total income flowing into the region. A similar pattern, although less pronounced, occurs in the public sector. The travel sector includes accommodation and a portion of the retail and personal services trades. The accommodation portion of the travel sector declined by 17% from 1991 and 1996, but remains well above employment levels of the 1980s. Retail trade, which includes retail stores and restaurants, also increased in the latter half of the 1980s and continued to grow through the first half of the 1990s, albeit at a slower rate.

The remaining employment in the Mackenzie TSA is supported by construction employment not allocated to one of the major sectors, agriculture, mining (such as quarries), other transportation and manufacturing activities not associated with the major sectors.

The indirect and induced employment included in Figure 27 reflects the income spent by companies and employees and the number of jobs that depend on those expenditures. Employment multipliers illustrate this spending effect: a larger multiplier indicates that each job of a particular sector will support more business activity at supply and service companies, due to higher company revenues, supply requirements and wages. For example, estimates by the Ministry of Finance and Corporate Relations indicate that every 100 full-time direct forestry jobs in the Mackenzie TSA support an additional 30-51 indirect and induced full-time jobs, depending on the forestry activity (harvesting or processing). In comparison, every 100 full-time direct jobs in the tourism and business travel sector support an estimated 12 indirect and induced jobs*, and every 100 jobs in the public sector support an additional 17 indirect and induced jobs. The differences are due to larger spending patterns by forestry sector businesses and their employees, which tend to have higher revenues and incomes. The multipliers indicate how a change to a particular sector could affect the broader economy. Table 7 compares employment multipliers for sectors of the Mackenzie TSA economy.

Indirect and induced job
Indirect jobs are supported by direct business purchases of goods and services. Induced jobs are supported by employee purchases of goods and services; for example, at retail outlets.

7 Socio-Economic Analysis

Table 7. Employment multipliers, by sector Mackenzie Forest District, 1996

Basic sector*	Employment multiplier
Forestry: logging and manufacturing	1.30–1.51
Agriculture and food	1.15
Travel and tourism	1.12
Public sector	1.17
Mining	1.42
Construction	1.27

Source: B.C. Ministry of Finance and Corporate Relations. 1999. *The 1996 forest district tables.*

7.2 Mackenzie TSA forest industry

7.2.1 Current allowable annual cut

The current (effective September 1996) allowable annual cut (AAC) for the Mackenzie TSA is 2 947 363 cubic metres, plus a deciduous volume of 50 000 cubic metres. Table 8 provides a breakdown of the AAC by tenure type. Prior to the current level, the AAC was 2 951 121 cubic metres.

Basic sector
Sectors of the economy, such as forestry, tourism and mining, that create flows of income into the region and are assumed to be drivers of the local economy. Non-basic sectors, such as retail outlets, are supported by basic sectors.

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Table 8. Mackenzie TSA allowable annual cut, by licence type

	AAC (m^3)	Per cent (%) of total AAC
Forest licences — replaceable	2 586 862	86.3
Small Business Forest Enterprise Program (SBFEP)	207 940	6.9
Forest Service Reserve	29 511	1.0
Woodlot licences*	16 242	0.5
Forest licences, non-replaceable	106 808	3.6
Sub-total conventional	2 947 363	98.3
Sub-total deciduous	50 000	1.7
Total AAC	2 997 363	100.0

7.2.2 Mackenzie TSA harvest history

Table 9 summarizes the volume of timber harvested in the Mackenzie TSA from 1993 to 2000. The actual volume of timber harvested is an important indicator of forestry activity in the TSA. While the AAC is the maximum allowable annual harvest level, the actual volume of timber harvested in a particular year determines the level of economic activity. Differences in annual harvest levels are due to provisions for cut control[3] variations that allow licensees to vary their harvests based on operating and market conditions. If actual annual harvest levels are consistently less than the AAC, then forestry activity is below its full potential.[4]

In 2000, approximately 2.94 million cubic metres were harvested from the Mackenzie TSA (see Table 9). During the 1993–1997 cut control period, the full allocation of timber was harvested from the TSA. The latest cut control period runs from 1998 to 2002 and a similar level of harvesting activity is expected.

(3) Cut control regulations allow licensees to vary the volume between annual harvest and AAC by ± 50% per year, and by ± 10% over a five-year cut control period.

(4) Full potential referred to here is based on the allocated volumes of the AAC, and is not necessarily the same as full economic potential which is based on the international market for wood products.

Woodlot licence
An agreement entered into under the Forest Act. It allows for small-scale forestry to be practised in a described area (Crown and private) on a sustained yield basis.

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Table 9. Mackenzie TSA volumes billed, by licence type, 1993–2000

Tenure	Cubic metres (m^3)							
	1993	1994	1995	1996	1997	1998	1999	2000
Forest licences (FL)	2 936 783	2 485 149	2 862 027	2 339 350	2 251 906	2 088 731	2 467 586	2 594 383
Small Business Forest Enterprise Program (SBFEP)	549 775	387 353	290 345	25 069	72 646	68 948	141 481	147 040
Other[a]	38 034	58 475	123 772	202 306	223 828	204 578	237 263	200 275
Total	3 524 592	2 930 977	3 276 144	2 566 725	2 548 380	2 362 257	2 846 330	2 941 698
AAC[b]	2 951 121	2 951 121	2 951 121	2 997 363	2 997 363	2 997 363	2 997 363	2 997 363
Average harvest 1993–1997:	2 969 364							
Average harvest 1998–2000:	2 716 762							

Source: Ministry of Forests.

(a) "Other" consists of cutting permits such as rights-of-way, road permits and other small temporary permits.

(b) The AAC changed in September 1996.

7.2.3 Mackenzie TSA major licensees and processing facilities

Slocan Forest Products Ltd.

Slocan Forest Products Ltd. (Slocan) has a replaceable forest licence in the Mackenzie TSA to harvest 1 412 520 cubic metres of timber. In 2000, Slocan harvested 1 623 997 cubic metres. Table 10 outlines Slocan's recent harvest activity and 1997-1999 average employment levels associated with its Mackenzie TSA operations.

Table 10. Slocan volumes billed and provincial employment statistics

Allowable annual cut (AAC)	1 412 520 cubic metres
2000 harvest[a]	1 623 997 cubic metres
1997-1999 average volumes billed	330 731 cubic metres
Employment[b] (1997-1999 person-years)	
Harvesting and administration	388
Transport, road building and maintenance	41
Basic silviculture	61
Processing	472
Total	962

(a) Harvest levels include forest licence and cutting permit volumes.

(b) The employment figures relate to the 1997-1999 average volume of 1 330 731 cubic metres harvested from the Mackenzie TSA only and processed in British Columbia.

In 1999, Slocan operated 10 lumber mills, one pulp and paper mill, one oriented strandboard (OSB) mill and a veneer/plywood plant within British Columbia. Two of the lumber mills are located in the Mackenzie TSA. From 1997 to 1999, the Mackenzie mills processed a combined average of 1.3 million cubic metres of timber. All of the timber processed at the Mackenzie TSA mills comes from the Mackenzie TSA. Slocan's AAC apportionment has been sufficient to meet its local capacity requirements.

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Abitibi Consolidated Inc.

Abitibi Consolidated Inc. (Abitibi) has a replaceable forest licence in the Mackenzie TSA to harvest 1 115 625 cubic metres of timber. In 2000, Abitibi harvested an average of 1 160 813 cubic metres. Table 11 outlines Abitibi's recent harvest activity and 1997–1999 average employment levels associated with its Mackenzie TSA operations.

Table 11. Abitibi volumes billed and provincial employment statistics

Allowable annual cut (AAC)	1 174 342 cubic metres
2000 harvest[a]	1 160 813 cubic metres
1997-1999 average volumes billed[a]	1 129 501 cubic metres
Employment[b] (1997-1999 person-years)	
Harvesting and administration	394
Transport, road building and maintenance	42
Basic silviculture	79
Processing	593
Total	1,108

(a) Harvest levels include forest licence and cutting permit volumes.

(b) The employment figures relate to the 1997-1999 average volume of 1 129 501 cubic metres harvested from the Mackenzie TSA only and processed in British Columbia.

Abitibi operates two sawmills and a pulp and paper mill in the Mackenzie TSA. From 1997 to 1999, the sawmills processed an average of about 1.2 million cubic metres per year. The pulp and paper mill consumed an average of approximately 172 000 bone-dry units (BDUs) of wood chips per year during the same period, all of which come from its sawmill operations. Recent improvements to one of its sawmills have increased the overall capacity of the Mackenzie operations, such that its Mackenzie TSA timber supply can no longer fully meet the company's local production capacity.

Other licensees and processing facilities

The largest pulp mill in the Mackenzie TSA was recently purchased (March 2001) by Pope and Talbot Ltd. from Norske Skogindustrier ASA (Norske Skog). Norske Skog purchased the mill from Fletcher Challenge Canada Ltd. in 2000. From 1997 to 1999, the pulp mill processed an average of about 330 000 BDUs of wood chips per year. Pulp production in 1997 and 1998 was significantly lower than production in 1999, due to a labour-related shutdown and subsequent start-up. The mill employs about 250 people. The mill has no associated tenure in the Mackenzie TSA, but approximately 65% of its fibre comes from local mills, with the remainder from the Prince George and Dawson Creek Forest Districts. The pulp mill is not able to fulfil its fibre requirements with timber and residual fibre from the Mackenzie TSA. Nonetheless, the mill could not operate without its Mackenzie TSA sources.

The rest of the Mackenzie TSA timber supply is harvested under the Small Business Forest Enterprise Program (SBFEF). In 2000, the total volume harvested under the SBFEP was 147 040 cubic metres. From 1997 to 1999 the average harvest was 94 358 cubic metres per year. On average, 79% of the timber harvested was scaled in the Mackenzie TSA, 17% in the Prince George TSA and 4% in the Vanderhoof Forest District.

Two of the larger SBFEP companies are East Fraser Fibre Co. Ltd. and M&T Wood Products Ltd. Each of these companies also operates a processing facility in the Mackenzie TSA. East Fraser Fibre operates a chipping facility in Mackenzie. In 2000, East Fraser harvested 79 636 cubic metres and from 1997 to 1999 harvested an average of 38 375 cubic metres of timber per year. In 2000, M&T harvested 34 500 cubic metres of timber and from 1997 to 1999 harvested an average of 31 000 cubic metres of timber per year.

Two other companies, Tsay Keh Dene First Nation and Akie Gataga Forest Ltd., have non-replaceable forest licences to harvest 53 404 cubic metres of timber per year. However, both licences were awarded in the latter half of 2000 and no volumes were harvested during the assessment period of this analysis. The volume, and its likely employment, is included in the assessment of future activity, however.

7.2.4 Forestry sector employment and employment coefficients

The preceding harvesting and employment information is used to develop employment coefficients, which are used to project future employment levels in the forestry sector. For this purpose, the forestry sector has been divided into three sub-sectors:

- harvesting and other woodlands-related employment including falling, log salvage, log scaling, log transport, harvest planning and administration;
- silviculture employment such as planting, surveying and other basic and intensive silviculture activities, such as spacing, fertilization and pruning*; and
- primary timber processing employment at lumber mills, veneer and plywood mills, shake and shingle mills, chip mills, log home mills and pulp and paper mills.

Pruning
The manual removal of the lower branches of crop trees to a predetermined height to produce clear, knot-free wood.

Harvesting and silviculture employment

The harvesting sub-sector of the forest industry includes both company and contract loggers and is the first sub-sector that a change in the AAC would affect. The predominant silvicultural system used in the Mackenzie TSA is clearcutting using ground-based cut-to-length, cable, and helicopter yarding systems. The active logging season can run all year, but varies by company and weather conditions. Generally, roads are impassable during the spring months and companies are unable to transport logs. Local residents account for an average of about 25–30% of the harvesting workforce.

The silviculture sub-sector is perhaps the least tied to the current level of harvest, given that silviculture activities are ongoing for 10–15 years following harvesting. Basic silviculture consists of pre- and post-harvest surveys, site preparation, planting, brushing, cone collecting and some spacing. Enhanced, or intensive, silviculture includes spacing, fertilization and pruning. In the TSA, major licensees are responsible for basic silviculture on areas harvested under major licences. The provincial government is responsible for the remaining basic and all enhanced silviculture on Crown land, which is completed by silviculture contractors.

Employment data compiled for this timber supply review indicate that from 1997 to 1999, the average TSA harvest of about 2 585 656 cubic metres per year supported about 978 person-years annually of direct harvesting and silviculture employment across the province. About 30% of this workforce resides in Mackenzie. According to the previous socio-economic assessment for the Mackenzie timber supply review, the average 1991–1994 harvest of 2 838 690 supported about 1,020 person-years of direct harvesting and silviculture employment across the province.

Processing employment

From 1997 to 1999, an average of about 2.8 million cubic metres of timber per year was processed in the Mackenzie TSA. The timber processed at local mills comes mainly from the TSA, with some supplies coming from other districts in the Prince George Forest Region.

Employment data compiled for this timber supply review indicate that, from 1997 to 1999, the TSA harvest of about 2 585 656 cubic metres per year supported approximately 1,290 person-years (three-year average) of direct processing employment across the province. About 98% of this processing employment is associated with operations in the Mackenzie TSA. According to the previous socio-economic assessment for the Mackenzie TSA timber supply review, the average 1993–1995 harvest of 2 838 690 cubic metres per year supported about 1,500 person-years of direct processing employment across the province.

Forest Service employment

The Mackenzie Forest District office in the municipality of Mackenzie administers the Mackenzie TSA. Currently, 55 people work in the forest district office. Forest Service staff are involved in administration, enforcement of government policy and SBFEP-related planning for the Mackenzie TSA.

7 Socio-Economic Analysis

Mackenzie TSA employment coefficients

Table 12 summarizes the employment supported by the 1997–1999 average harvest in the Mackenzie TSA and the corresponding employment coefficients. These coefficients have been calculated for the TSA and province to highlight the level of forestry activity within the Mackenzie TSA and to identify the contribution that the Mackenzie TSA's forestry sector makes to the provincial economy. The two employment levels are defined as follows:

1. TSA employment and employment coefficients, which comprise residents of the Mackenzie TSA who are employed in the forestry sector within the Mackenzie TSA and who rely on the Mackenzie TSA timber supply; and
2. Provincial employment and employment coefficients, which comprise all forestry sector employment in the province that relies on the Mackenzie TSA timber supply, including both residents of the Mackenzie TSA and those who live elsewhere.

Employment is divided into direct, indirect and induced components; the sum of the components is the total impact. The coefficients are expressed as the number of full-time jobs, or person-years, per 1000 cubic metres of timber harvested. Indirect and induced employment figures were derived using employment multipliers developed by the Ministry of Finance and Corporate Relations.

More detailed information regarding employment coefficients and multipliers is presented in Appendix B, "Socio-Economic Analysis Background Information."

Table 12. Mackenzie TSA employment and employment coefficients,[5] average 1996–1998

Forest industry activity	TSA employment (person-years)	TSA coefficients (person-years/'000s m³)	Provincial employment (person-years)	Provincial coefficients (person-years/'000s m³)
Harvesting	268	0.10	822	0.32
Silviculture	24	0.01	156	0.06
Processing	1,266	0.49	1,288	0.50
Total direct	1,559	0.60	2,266	0.88
Indirect + induced	566	0.22	3,080	1.19
Total employment	2,124	0.82	5,346	2.07

Note: Employment estimates are reported in person-years based on average 1997–1999 employment levels and the average 1997–1999 Mackenzie TSA harvest of 2 585 656 cubic metres per year. Figures may not be exact due to rounding.

(5) Other employment coefficients may be found in other documents for the same or similar areas. A difference in ratios can occur for several reasons, such as using different sources of employment data, rounding of estimates, dividing employment by a different harvest level, using a different definition of a full-time position and changing the definition of forestry sub-sectors. However, the size of impacts associated with a timber supply change should illustrate similar effects.

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7.2.5 Mackenzie TSA employment income

From 1997 to 1999, the average income for forestry sector employees associated with the Mackenzie TSA was about $48,550, based on average provincial income levels for logging and forestry services, solid wood manufacturing and pulp and paper manufacturing (see Appendix B). Average income for indirect and induced sector employees was $30,300. The total direct income associated with the forestry sector in the Mackenzie TSA averaged $110.0 million per year and total income for indirect and induced employment averaged $93.3 million per year (incomes are reported in 1998 dollar values). Combined, total employment income in the Mackenzie TSA averaged $203.3 million per year. Table 13 shows income levels, average wages and salaries and total income per 1000 cubic metres of harvested timber.

Table 13. Average direct and indirect and induced incomes and total employment income, 1997–1999

	Average wage ($ 1998)	Total income ($ millions)	Total income ($/'000s m^3)
Direct	48,550	110.0	42,550
Indirect + Induced	30,300	93.3	36,095
Total income		203.3	78,545

Sources: Statistics Canada. *Annual estimates of employment, earnings and hours*. Internet, www.statcan.ca/start.html.
Statistics Canada. Labour Force Survey, average weekly wage rate. Internet, www.statcan.ca/start.html.

7.2.6 Provincial government revenues

The provincial government receives various taxes and other revenues from the forest industry. The forest industry pays stumpage, royalties and rents to the provincial government for the rights to timber and its use, and other industry operating taxes such as corporate income, property and sales taxes. The provincial and federal governments also receive revenues from forestry employees directly through income taxes.

From 1997 to 1999, forest industry activity in the Mackenzie TSA provided an average of about $67.1 million in annual stumpage, royalty and rent payments to the provincial government. Other government revenues from forest industry taxes accounted for $23.4 million per year. Total employment supported by the Mackenzie TSA harvest generated total annual provincial and federal income taxes worth $45 million. About one-third of the total income tax, or $15 million per year, goes to the provincial government. Table 14 shows average annual provincial government revenues for 1997-1999.

Table 14. Average annual provincial government revenues, 1997-1999

	Average annual revenue 1997-1999 ($ 1998 millions)	Average revenue ($/'000s m^3)
Stumpage, rents and royalties	67.1	25,750
Industry taxes	23.4	9,040
Provincial income tax	15.0	5,780
Total provincial government revenues	105.5	40,570

Sources: Ministry of Forests, Revenue Branch; PriceWaterhouseCoopers, 1999.

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7.3 Socio-economic implications of the base case harvest forecast

The socio-economic analysis focuses on harvest level changes in the short- to mid-term of 10-30 years from now and considers:

- the implications of alternative harvest levels for both the Mackenzie TSA and the province;
- possible impacts on communities within the TSA;
- timber requirements of processing facilities within the Mackenzie TSA; and
- regional timber supply implications.

The socio-economic analysis considers average levels of forest industry related activity that the base case harvest forecast could support. Impacts associated with future harvest levels are calculated using employment, income and revenue coefficients (per 1000 cubic metres). This method assumes that the current role of the forest industry in the provincial economy and labour productivity will not change. In other words, employment levels in the future can be predicted based on today's relationship between employment and the volume of timber harvested and processed. The analysis also assumes that the proportions of harvesting, silviculture and timber processing employment will remain constant and that the types and proportions of wood products manufactured will remain the same.

While this method is reasonably accurate for short-term forecasts (within the next five years), employment coefficients 20 years from now may differ due to changes in market conditions, timber processing technologies, etc. The analysis indicates the magnitude of impacts to employment, employment income and provincial government revenues, within a constantly changing socio-economic environment.

7.3.1 Short- and long-term implications of alternative harvest levels

Employment and income impacts in the Mackenzie TSA

Mackenzie TSA employment and income impacts focus on those workers who are supported by the TSA harvest and who reside within the TSA. Workers who come to the TSA to work but who reside outside the TSA are included in the provincial impact section, as are those supported by Mackenzie TSA timber processed at mills outside the forest district. Table 15 indicates the employment and income that the current AAC could support if fully harvested and processed.

The current AAC of 2 997 363 cubic metres, if fully harvested, can support about 1,800 person-years of direct employment and a further 650 person-years of indirect and induced employment within the TSA. This level of employment would result in about $107 million in annual total employment income.

From 1997 to 1999, the average harvest level was 2 585 656 cubic metres per year and in 2000 the harvest increased to fully harvest the apportioned timber. While the 1997–1999 average annual harvest level is below the AAC, it is well within the allowance for cut control variations of plus or minus 50% per year. The full AAC allotment was taken during the 1993–1997 cut control period and is expected to be harvested in the current cut control period ending in 2002. The current average harvest rate is within 10% of the current AAC. As such, this assessment is based on the assumption that the forest sector is achieving its full potential and will operate at or near full employment, given normal fluctuations in harvest rates.

Given the long-term stability of the timber supply as indicated by the timber supply forecast, it is assumed that employment associated with the Mackenzie TSA will remain at or near its current level. Annual employment will experience marginal fluctuations as harvest levels rise and fall to market conditions and any change in the demand for wood products or manufacturing productivity will also affect the total employment supported by the forest sector.

Provincial employment and income impacts

Provincial employment and income impacts include all the activity supported by the Mackenzie TSA harvest, regardless of processing location and place of residence.

The current AAC of 2 997 363 cubic metres can support about 2,600 person-years of direct employment and a further 3,550 person-years of indirect and induced employment across the province. This level of employment results in $235 million in annual total provincial employment income.

As with the TSA assessment, given the long-term stability of the timber supply, employment levels are assumed to remain approximately the same.

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Table 15. Socio-economic impacts of Mackenzie TSA base case harvest forecast

	At current harvest rate[a]	Base case harvest forecast
	cubic metres (m^3)	
Harvest level (1997–1999 average)	2 585 656	2 997 363
Timber supply (current AAC)	2 997 363	
Difference from current AAC	(361 707)	0
Mackenzie TSA		
Employment	(person-years)	
Direct	1,559	1,805
Indirect + Induced	566	655
Total	2,124	2,460
Range of employment gain (loss)		302-336
Employment Income	($1998 million per year)	
Direct	75.2	87.0
Indirect + Induced	17.1	20.0
Total	92.3	107.0
Range of income gain (loss)		13.2-14.7
Province[b]		
Employment	(person-years)	
Direct	2,266	2,625
Indirect + Induced	3,080	3,570
Total	5,346	6,195
Range of employment gain (loss)		713-849
Employment Income	($1998 million per year)	
Direct	109.3	126.7
Indirect + Induced	93.3	108.2
Total	202.6	234.9
Range of income gain (loss)		27.1-32.3
Provincial government revenues	($1998 million per year)	
Stumpage and related payments	66.6	77.2
Forest industry taxes	23.4	27.1
Employee income taxes	15.0	17.3
Total	105.0	121.6
Gain (reduction) in revenues		16.6

(a) Estimates for current employment differ from those in Table 12. Current employment figures in Table 15 are based on the current AAC of 2 997 363 cubic metres; figures in Table 12 are based on the 1997–1999 annual average harvest of 2 585 656 cubic metres.

(b) TSA employment and income estimates are included in the provincial employment and income estimates.

Provincial government revenue impacts

Provincial government revenues from the forest industry include stumpage, royalties and rent payments; other taxes such as logging, corporate income, sales, property and electricity taxes; and income taxes from direct, indirect and induced employees. Under the existing tax and stumpage regimes, the current AAC of 2 997 363 cubic metres, if fully harvested, would provide on average about $120 million annually to the provincial government.

7.3.2 Community-level impacts

The impacts related to changes in the timber supply can affect the socio-economic environment of a community. A reduction in employment and income could affect various socio-economic conditions in communities (for example, population growth rates, the size of the labour force, social stress, economic development opportunities and government-funded services). These changes would have a greater effect on an economy dependent on a single industry than on one that is more diversified and experiencing growth in other sectors.

The economy of Mackenzie depends on the forest sector for 65% of its employment and 71% of its total income.[6] The community was built for and continues to rely heavily on timber harvested and milled in the area. Any sizable reduction in the harvest level or shift in processing location would have a large impact on the local economy. Given the current review of the timber supply, this scenario is unlikely, at least in the foreseeable future.

7.3.3 Nature, production capabilities and timber requirements of processing facilities

The current milling structure of the Mackenzie TSA consists of four large sawmills, two pulp mills, a paper mill and several smaller producers of chips, lumber and other value-added products. From 1997 to 1999, the average annual volume of logs processed by local mills was about 2.8 million cubic metres and the two pulp mills processed an average 400 000-600 000 BDUs of chips. Solid wood and chip mills in the TSA produced an average of about 400 000 BDUs of wood chips, indicating the Mackenzie TSA is a net importer of wood chips.

7.3.4 Regional timber supply issues

The regional timber supply is an important consideration when examining potential future impacts of timber supply changes. The Prince George Forest Region supplies timber to mills throughout the northern half of the province and to some in the southern Interior and Coast. From 1997 to 1999, solid wood mills in the Prince George Forest Region processed an average of 18.3 million cubic metres of timber per year. Timber from the Prince George TSA accounts for about 50% of the region's consumption.

Over the next 25 years, timber supply forecasts indicate that the average annual harvest in the Prince George Forest Region could remain relatively constant around 19–20 million cubic metres.[7] The Prince George Forest Region has the most stable timber supply in the province.

(6) B.C. Ministry of Finance and Corporate Relations. 1999. *The 1996 forest district tables*.

(7) The current AAC for the Prince George Forest Region totals 19.4 million cubic metres. Current timber supply forecasts indicate that the timber supply in the Prince George Forest Region could be approximately 19.8 million cubic metres per year by approximately 2020.

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7.4 Summary

The forest industry in the Mackenzie TSA is the most important source of employment and income for local residents. The public sector, the second-leading employer in the TSA, depends on the population and service requirement levels of the community. As such, it is also tied to the forest industry.

The current AAC of 2 997 363 cubic metres, if fully harvested and processed, can support about 2,600 person-years of direct forestry employment and a further 3,500 person-years of indirect and induced employment across the province. Residents of the Mackenzie TSA account for about 69% of the direct employment. The employment income associated with this direct, indirect and induced employment would be about $235 million per year. The employment and income levels (in real terms) can be expected to continue, given the stable timber supply indicated by the timber supply forecast.

The average harvest from 1997 to 1999 was 2 585 656 cubic metres per year and in 2000 was 2 941 698 cubic metres. Licensees achieved the previous cut control requirements and there is no indication that the current cut control will not be met.

Based on the average 1997–1999 harvest, the provincial government currently collects about $105 million per year in stumpage and related payments, other industry taxes and provincial income taxes. Fully harvesting the apportioned volumes of timber in the Mackenzie TSA could increase annual revenues by as much as $16 million, most of which would be stumpage and related payments.

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9 Glossary

Allowable annual cut (AAC)

The rate of timber harvest permitted each year from a specified area of land, usually expressed as cubic metres of wood per year.

Analysis unit

A grouping of types of forest — for example, by species, site productivity, silvicultural treatment, age, and or location — done to simplify analysis and generation of timber yield tables.

Base case harvest forecast

The timber supply forecast which illustrates the effect of current forest management practices on the timber supply using the best available information, and which forms the reference point for sensitivity analysis.

Basic sector

Sectors of the economy, such as forestry, tourism and mining, that create flows of income into the region and are assumed to be drivers of the local economy. Non-basic sectors, such as retail outlets, are supported by basic sectors.

Biodiversity (biological diversity)

The diversity of plants, animals and other living organisms in all their forms and levels of organization, including the diversity of genes, species and ecosystems, as well as the evolutionary and functional processes that link them.

Biogeoclimatic (BEC) variant

A subdivision of a biogeoclimatic zone. Variants reflect further differences in regional climate and are generally recognized for areas slightly drier, wetter, snowier, warmer or colder than other areas in the subzone.

Biogeoclimatic zones

A large geographic area with broadly homogeneous climate and similar dominant tree species.

Clearcut harvesting

A harvesting method in which all trees are removed from an area of land in a single harvest. The harvested site is then regenerated to acceptable standards by appropriate means including planting and natural seeding. Note that retention of some live trees and snags for purposes of biodiversity now occurs on most clearcuts.

Coniferous

Coniferous trees have needles or scale-like leaves and are usually 'evergreen'.

Culmination age

The age at which a timber stand reaches its highest average growth rate, or mean annual increment (MAI). MAI is calculated as stand volume divided by stand age. Culmination age is the optimal biological rotation age to maximize long-term volume production from a growing site.

9 Glossary

Cultural heritage resource

An object, a site or the location of a traditional societal practice that is of historical, cultural or archaeological significance to the province, a community or an aboriginal people.

Cutblock

A specific area, with defined boundaries, authorized for harvest.

Deciduous

Deciduous trees commonly have broad-leaves and usually shed their leaves annually.

Early seral

Stands are defined as early seral if they are younger than 40 years of age. An exception is deciduous-dominated stands in the Boreal White and Black Spruce biogeoclimatic zone, which are defined as early seral up to 20 years of age.

Employment coefficient

The number of person-years of employment supported by every 1000 cubic metres of timber harvested; for example, a coefficient of 1.0 indicates that every 1000 cubic metres harvested supports one person-year, or 500 000 cubic metres supports 500 person-years.

Employment multiplier

An estimate of the total employment supported by each direct job, for example a multiplier of 2.0 means that one direct job supports one additional indirect and induced job.

Environmentally sensitive areas

Areas with significant non-timber values, fragile or unstable soils, impediments to establishing a new tree crop, or high risk of avalanches.

Forest cover objectives

Specify desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest cover objectives (see **Green–up**).

Forest cover requirements

Specify desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest cover objectives (see **Green–up**).

9 Glossary

Forest inventory	An assessment of British Columbia's timber resources. It includes computerized maps, a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, and a description of other forest values such as recreation and visual quality.
Forest Practices Code	Legislation, standards and guidebooks that govern forest practices and planning, with a focus on ensuring management for all forest values.
Forest type	The classification or label given to a forest stand, usually based on its tree species composition. Pure spruce stands and spruce-balsam mixed stands are two examples.
Free-growing	An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.
Green-up	The time needed after harvesting for a stand of trees to reach a desired condition (usually a specific height) — to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics — before harvesting is permitted in adjacent areas.
Growing stock	The volume estimate for all standing timber at a particular time.
Harvest forecast	The flow of potential timber harvests over time. A harvest forecast is usually a measure of the maximum timber supply that can be realized over time for a specified land base and set of management practices. It is a result of forest planning models and is affected by the size and productivity of the land base, the current growing stock, and management objectives, constraints and assumptions.
Higher level plans	Higher level plans establish the broader, strategic context for operational plans, providing objectives that determine the mix of forest resources to be managed in a given area.
Indirect and induced jobs	Indirect jobs are supported by direct business purchases of goods and services. Induced jobs are supported by employee purchases of goods and services; for example, at retail outlets.

9 Glossary

Inoperable areas

Areas defined as unavailable for harvest for terrain-related or economic reasons. Characteristics used in defining inoperability include slope, topography (e.g., the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality. Operability can change over time as a function of changing harvesting technology and economics.

Integrated resource management (IRM)

The identification and consideration of all resource values, including social, economic and environmental needs, in resource planning and decision-making.

Land and Resource Management Plan (LRMP)

A strategic, multi-agency, integrated resource plan at the subregional level. It is based on the principles of enhanced public involvement, consideration of all resource values, consensus-based decision making, and resource sustainability.

Landscape-level biodiversity

The *Landscape Unit Planning Guide* provides objectives for maintaining biodiversity at both the landscape level and the stand level. At the landscape level, guidelines are provided for the maintenance of seral stage distribution, patch size distribution and landscape connectivity.

Landscape unit

A planning area based on topographic or geographic features, that is appropriately sized (up to 100 000 hectares), and designed for application of landscape-level biodiversity objectives.

Long-term harvest level

A harvest level that can be maintained indefinitely given a particular forest management regime (which defines the timber harvesting land base, and objectives and guidelines for non-timber values) and estimates of timber growth and yield.

Management assumptions

Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specification of minimum harvestable ages, utilization levels, integrated resource guidelines and silviculture and pest management programs.

9 Glossary

Model	An abstraction and simplification of reality constructed to help understand an actual system or problem. Forest managers and planners have made extensive use of models, such as maps, classification systems and yield projections, to help direct management activities.
Not satisfactorily restocked (NSR) areas	An area not covered by a sufficient number of well-spaced tree stems of desirable species. Stocking standards are set by the B.C. Forest Service. Areas harvested prior to October 1987 and not yet sufficiently stocked according to standards are classified as backlog NSR. Areas harvested or otherwise disturbed since October 1987 are classified as current NSR.
Operability	Classification of an area considered available for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.
Partition	A portion of the AAC that is attributable to certain types of timber and/or terrain.
Person-year(s)	One person working the equivalent of one full year, defined as at least 180 days of work. Someone working full-time for 90 days accounts for 0.5 person-years.
Protected area	A designation for areas of land and water set aside to protect natural heritage, cultural heritage or recreational values (may include national park, provincial park, or ecological reserve designations).
Pruning	The manual removal of the lower branches of crop trees to a predetermined height to produce clear, knot-free wood.
Regeneration delay	The period of time between harvesting and the date at which an area is occupied by a specified minimum number of acceptable well-spaced trees.
Riparian area	Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.
Scenic area	Any visually sensitive area or scenic landscape identified through a visual landscape inventory or planning process carried out or approved by a district manager.

9 Glossary

Sensitivity analysis	A process used to examine how uncertainties about data and management practices could affect timber supply. Inputs to an analysis are changed, and the results are compared to a baseline or base case.
Site index	A measure of site productivity. The indices are reported as the average height, in metres, that the tallest trees in a stand are expected to achieve at 50 years (age is measured at 1.3 metres above the ground). Site index curves have been developed for British Columbia's major commercial tree species.
Stand-level biodiversity	A stand is a relatively localized and homogeneous land unit that can be managed using a single set of treatments. In stands, objectives for biodiversity are met by maintaining specified stand structure (wildlife trees or patches), vegetation species composition and coarse woody debris levels.
Stocking	The proportion of an area occupied by trees, measured by the degree to which the crowns of adjacent trees touch, and the number of trees per hectare.
Timber harvesting land base	Crown forest land within the timber supply area where timber harvesting is considered both acceptable and economically feasible, given objectives for all relevant forest values, existing timber quality, market values and applicable technology.
Timber supply	The amount of timber that is forecast to be available for harvesting over a specified time period, under a particular management regime.
Timber supply area (TSA)	An integrated resource management unit established in accordance with *Section 7* of the *Forest Act*.
Table Interpolation Program for Stand Yields	A B.C. Forest Service computer program used to generate yield projections for managed stands using a model that simulates the growth of individual trees based on internal growth processes, crown competition, environmental factors and silvicultural practices.
Unsalvaged losses	The volume of timber killed or damaged annually by natural causes (e.g., fire, wind, insects and disease) and not harvested.

9 Glossary

Variable Density Yield Prediction model	An empirical yield prediction system supported by the B.C. Forest Service, designed to predict average yields and provide forest inventory updates over large areas (i.e., Timber Supply Areas). It is intended for use in unmanaged natural stands of pure or mixed composition.
Visual quality objective (VQO)	Defines a level of acceptable landscape alteration resulting from timber harvesting and other activities. A number of visual quality classes have been defined on the basis of the maximum amount of alteration permitted.
Volume estimates (yield projections)	Estimates of yields from forest stands over time. Yield projections can be developed for stand volume, stand diameter or specific products, and for empirical (average stocking), normal (optimal stocking) or managed stands.
Watershed	An area drained by a stream or river. A large watershed may contain several smaller watersheds.
Wildlife tree	A standing live or dead tree with special characteristics that provide valuable habitat for conservation or enhancement of wildlife.
Woodlot licence	An agreement entered into under the *Forest Act*. It allows for small-scale forestry to be practised in a described area (Crown and private) on a sustained yield basis.

Appendix A

Description of Data Inputs and Assumptions for the Timber Supply Analysis

Introduction

The following tables and discussion outline the methods and inputs used to derive the timber harvesting land base, and to construct the timber supply model for the Mackenzie TSA timber supply analysis. This information represents current forest management in the area.

Current management is defined as the set of land-use decisions and forest and stand management practices currently implemented and enforced. Future forest management objectives that may be intended, but are not currently implemented and enforced, are not included in this appendix.

The purpose of the timber supply review is to provide information on the effects of current management on both short- and long-term timber supplies in each timber supply area in the province. Any changes in forest management objectives and practices, and any improvements to the data will be included in subsequent timber supply analyses.

More detail on the derivation of many of the land base exclusions and modelling approaches is available in the April 2000 *Mackenzie Timber Supply Area timber supply review Data Package*.

A.1 Inventory Information

Table A-1. Inventory information

Data	Source	Vintage	Update	Scale
Forest cover inventory	MoF	1999	1998/1999	1:20 000
Biogeoclimatic	MoF – Research Branch	1998	1998	1:250 000
Natural disturbance type (NDT)	MoF – Research Branch	1997	1998	1:250 000
Resource management zones – (proposed)	MoF/MELP	1996 – 1997		1:250 000
Protected areas (proposed LRMP)	MoF/MELP			1:250 000
Physical operability logging system	MoF	1998	2000	1:250 000
District haul zones	MoF	1995	2000	1:250 000
Visual landscape inventory (recommended VQOs): 1) Current known scenic areas 2) LRMP proposed scenic areas/VQOs	MoF	1998	1999	1:250 000
Landscape units (draft)	MoF	1996	1998	1:250 000
Biodiversity emphasis options 1) Interim 2) Revised–April/98 RLUP	MoF/MELP	 1) 1996 2) 1998		1:250 000
Planning cells	MoF	1991	2000	1:50 000
Terrain stability	Licensees/FRBC	1998	1998	1:20 000
Recreation inventory	MoF	1993 -1998	1998	1:50 000
Wildlife habitat				
– Caribou management strategy	MELP/LRMP	1998		1:250 000
– Grizzly bear management strategy	MELP/LRMP	1999		1:250 000
– Moose management strategies	LRMP	1999		1:250 000
– Arctic grayling management strategy	MELP	1995		
Mugaha marsh sensitive area proposal	MELP	1998		1:20 000
Woodlot update	MoF	1988	1998	1:20 000
McLeod Lake Treaty 8 map	MoF	1999		1:20 000

Data source and comments:

Forest cover inventory – forest inventory file has been projected for growth to 1999 for the Mackenzie TSA.

The updated forest cover file contains new physical operability information. Re-inventory is complete for most of the TSA. Re-inventory of the northern third is still incomplete due to a lack of aerial photography in this area.

Backlog silviculture database: based on aerial photography, information on approximately 2500 pre-1987 openings is available in a Geographic Information System (GIS) database, providing silviculture and ground survey information.

A.2 Zone and Analysis Unit Definition

A.2.1 Management zones, groups and multiple objectives

Table A-2. Objectives to be tracked

Group	Description	Inventory definition	Function
1	Timber harvesting land base by landscape unit	Crown forested operable area where timber harvesting may occur.	Reporting. Provide an assessment of the timber harvesting land base by landscape unit.
2	All forested land by landscape unit	Type ID projected 1, 2, 3, 4 and 9.	Reporting. Provide an assessment of the total forest by landscape unit. All Crown forest included.
3	Landscape-level biodiversity — all forest	Non-standard mapped layer.	Application of biodiversity targets at the landscape unit/emphasis/BEC zone-variant level. All Crown forest included.
4	Visual quality	Non-standard mapped layer.	Resource emphasis area — visual quality. Application of visual quality objective (VQO) guidelines by landscape unit. Total forest included. Retention (R), partial retention (PR), and modification (M) will be modelled.
5	Integrated resource management (IRM)	Crown forested: operable area where timber production is the primary objective.	No specific forest requirements applied. IRM forest cover requirements are expected to be achieved through management for landscape- and stand-level biodiversity.
6	Harvesting opportunities by distance	Timber harvesting land base.	Harvest emphasis: near zone (immediately available for harvesting) and far zone (harvesting is limited by distance).
7	Draft land and resource management plan (LRMP)	Crown forested operable area. Non-standard mapped layer	Objectives from the draft LRMP.
8	Wildlife habitat	Non-standard mapped layer.	Objectives from the draft LRMP strategies

A.2 Zone and Analysis Unit Definition

A.2.2 Analysis units

An analysis unit represents a combination of stands dominated by specific tree species or silviculture regime with a specific timber growing capability, as indicated by the inventory type group and site index in the forest inventory file. Each analysis unit is assigned its own timber volume projections (yield tables) for existing and future stands.

Table A-3. Definition of analysis units

Analysis unit number and leading tree species	Inventory type groups	Site productivity	Site index[a] range
1. Balsam	18-20	Good	= > 13
2. Balsam	18-20	Medium	10 < = < 13
3. Balsam	18-20	Poor	< 10
4. Spruce	21-26	Good	= > 16
5. Spruce	21-26	Medium	10 < = < 16
6. Spruce	21-26	Poor	< 10
7. Pine	28-31	Good	> 17
8. Pine	28-31	Medium	14 < = < 17
9. Pine	28-31	Poor	< 14
10. Poplar/Cottonwood	35, 36	Good/medium	> 18
11. Aspen	41, 42	Good/medium	> 18
12. Birch	40	Good/medium	> 18

(a) Site index is the expected tree height, in metres, at breast height at age 50 years.

A.3 Timber Harvesting Land Base Definition

A.3.1 Land not managed by the B.C. Forest Service

Ownership codes were generally used to identify whether the land was expected to contribute to timber supply. Ownership codes 62C and 69C indicate Crown land in a forest management unit and miscellaneous reserves, respectively. All areas with other ownership codes were removed from the land base considered available for timber supply. These included areas under woodlot licences because their AACs were determined and administered independently from the timber supply review process.

A.3.2 Land classified as protected area and wildland

The protected area and wildland identified in the LRMP have been legalized and excluded.

A.3.3 Land classified as non-forest or non-productive forest

Type identity 6 areas such as alpine, lakes, rocks, power lines, highway, etc. and type identity 8, where no typing is available, were excluded from the land base considered for timber supply.

A.3.4 Non-commercial cover

Type identity 5 represents areas currently occupied by non-commercial brush species. These areas were considered unlikely sites for timber production and were excluded from the area considered available for timber harvesting.

A.3.5 Areas considered inoperable

Operability classification accounts for the presence or absence of physical and economic barriers to harvesting the different forest stands found in the Mackenzie TSA. Operability is influenced by three main variables: physical operability (logging chance based on slope classes and soils that is expressed as conventional, cable, helicopter, or inoperable); development/haul zone (near or far based on proximity to Mackenzie); and forest stand attributes (age, height, stocking, and site index classes).

Table A-4. deals with economic operability, which is affected by forest attributes and distance from mills. Physical operability combines slope and soils information into five spatially explicit classes described in Table A-5.

Table A-4. Description of inoperable areas

Inventory description	Code	Reduction per cent (%)
Conventional harvesting practices	A	0
Cable harvesting practices	C	0
Cable or helicopter harvesting practices	H	0
Inoperable areas	I	100
Not typed	N	100

Data source and comments:

1. Conventional harvest — slopes < 55% (< 30% on lacustrine soils);
2. Cable harvest — slopes from 55- 100% (30- 100% on lacustrine soils);
3. Cable or helicopter harvest — slopes > 100%; and
4. Inoperable — unstable lacustrine soils identified by regional photo interpretation.

A.3 Timber Harvesting Land Base Definition

Table A-5. Area exclusion factors for merchantable stands for conventional (Conv), cable, and helicopter (Heli) logging in near and far zones used in the base case

	Harvest zone:	Near[b]			Far			
	Logging system:	Conv	Cable	Heli[c]	Conv	Conv	Cable	Heli
Type group number (leading species)	Age, height and stocking class				Slope < 30%	Slope > 30%		
18 – 20	Age ≥ 7, Height<2	100[d]	100	100	100	100	100	100
(Balsam)	742, 842, 942	0	100	100	0	0	100	100
B, BH, BS	732, 832, 932	0	100	100	0	0	100	100
	(721, 821, 921)[a]	0	100	100	100	100	100	100
	(722, 822, 922)[a]	0	100	100	100	100	100	100
20 (BS)	Height ≥ 3, Stocking = 1	0	100	100	100	100	100	100
	Stocking = 2	100	100	100	100	100	100	100
	Height = 2, Stocking = 1	0	100	100	100	100	100	100
18 (B)	Height ≥ 3, Stocking = 1	0	100	100	100	100	100	100
	Stocking = 2	100	100	100	100	100	100	100
	Height = 2, Stocking = 1	100	100	100	100	100	100	100
21 – 26	Age ≥ 7, Height < 2,	100	100	100	100	100	100	100
(Spruce)	742, 842, 942	0	100	100	0	0	100	100
S, SF, SH,	732, 832, 932	0	100	100	0	0	100	100
SB, SPl,	(721, 821, 921)[a]	0	100	100	100	100	100	100
& Sdec	(722, 822, 922)[a]	0	100	100	100	100	100	100
	Height ≥ 3 Stocking = 1	0	0	0	0	100	100	100
	Height ≥ 3 Stocking = 3	0	100	100	0	100	100	100
	Height = 2, Stocking = 1, 2	0	100	100	0	100	100	100
28 – 31	Age ≥ 5, Height < 2	100	100	100	100	100	100	100
(Pine)	542, 642, 742, 842, 942	0	100	100	0	0	100	100
Pl, PlF,	532, 632, 732, 832, 932	0	100	100	0	0	100	100
PlS, & PlDec	(521, 621, 721, 821, 921)[a]	0	100	100	100	100	100	100
	(522, 622, 722, 822, 922)[a]	0	100	100	100	100	100	100
	(533, 633, 733, 833, 933)[a]	0	100	100	100	100	100	100
	(534, 634, 734, 834, 934)[a]	0	100	100	100	100	100	100
	(523, 623, 723, 823, 923)[a]	0	100	100	100	100	100	100
	(524, 624, 724, 824, 924)[a]	0	100	100	100	100	100	100
	Height ≥ 3 Stocking = 1	0	100	100	0	100	100	100
	Height ≥ 3 Stocking = 2, 3, 4	0	100	100	0	100	100	100
	Height = 2, Stocking = 1, 2, 3, 4	0	100	100	0	100	100	100
35,36, 40, 41, & 42	Age ≥ 4, Height < 2, All stock	100	100	100	100	100	100	100
(Cttnwd, Birch, &	Age ≥ 4, Height ≥ 2, Stock = 1	0	100	100	100	100	100	100
Aspen)	Age ≥ 4, Height ≥ 2, Stock not = 1	100	100	100	100	100	100	100

(a) Indicates stands listed in the row are marginal stands. Hence they may not be harvestable in poor market years or if they are overly abundant in particular areas. Sensitivity analyses was investigated the effect of excluding all or a portion of these stands in the near zone, as well as including a portion or all in the far zone.

(b) The near zone for deciduous-leading stands extends north from the southern boundary approximately to the Peace Arm.

(c) There were no existing or planned operations in the helicopter zone.

(d) 100 indicates stands that were not excluded and 0 indicates that the stands were excluded as unmerchantable.

A.3 Timber Harvesting Land Base Definition

A.3.5 Environmentally sensitive areas

Some forest lands are environmentally sensitive and/or significantly valuable for other resources. These areas were identified and delineated during a forest inventory as environmentally sensitive areas (ESAs).

Table A-6. Description of environmentally sensitive areas

ESA category	ESA description	Reduction per cent (%)
Es1	Extremely unstable soils	100
Es2	Unstable soils but less than Es1	50
Ep1	Severe regeneration problems caused by geoclimatic factors	100
Ep2	Regeneration problems caused by biotic factors	70
Ea	Severe snow chute and avalanche problems	100
Er1	Exceptionally high recreational values	100
Er2	High recreational values but less than Er1	70
Ew1	Critical importance to wildlife	100
Ew2	High value for wildlife but less than Ew1	70
Eh1	Extremely high watershed values	100
Eh2	High watershed values but less than Eh1	70
Ec	Areas of management concern (any of the categories noted above but surveyed prior to 1976)	100

A.3.6 Sites with low timber growing potential

Sites may have low productivity either because of inherent site factors (nutrient availability, exposure, excessive moisture, etc.), or because they are not fully occupied by commercial tree species. Typically, these stands are intermixed with other stands within the forested land base. For the Mackenzie TSA, low productivity stands that are not expected to produce an economically harvestable crop of trees in a reasonable length of time were excluded from the timber harvesting land base.

A.3 Timber Harvesting Land Base Definition

Table A-7. Sites with low growing potential

Species	Balsam			Spruce			Pine		
Haul zone	Age	Volume	Site index	Age	Volume	Site index	Age	Volume	Site index
Near									
Logging system									
Conventional	140	180	8.9	140	190	8.9	120	170	11.1
Conventional/cable	140	180	8.9	140	200	9.2	120	190	11.7
Cable	140	N/A	N/A	140	240	10.3	120	N/A	N/A
Medium									
Logging system									
Conventional	140	190	9.2	140	190	9.2	120	170	11.1
Conventional/cable	140	200	9.4	140	200	9.4	120	200	12
Cable	140	N/A	N/A	140	240	10.3	120	N/A	N/A
Far									
Logging system									
Conventional	140	N/A	N/A	140	190	9.2	120	210	12.3
Conventional/cable	140	N/A	N/A	140	N/A	N/A	120	N/A	N/A
Cable	140	N/A	N/A	140	N/A	N/A	120	N/A	N/A

Data source and comments:

1. Older stands were excluded from the timber harvesting land base if the specified minimum volume per hectare was not met.
2. Younger coniferous stands were excluded from the timber harvesting land base if their site index was below that specified (the minimum required to reach a volume of 140 cubic metres per hectare by age 141).
3. Younger deciduous stands were excluded from the timber harvesting land base if their site index is below that specified (the minimum required to reach a height of 18 metres by age 81).
4. Old deciduous stands were excluded from the timber harvesting land base if their minimum volume per hectare did not reach 120 cubic metres at age 81.
5. Criteria for conifer species were developed based on current performance and discussions with regional analysts and licensees in the Mackenzie TSA.
6. Since there was very little deciduous performance history in the Mackenzie TSA, criteria for deciduous species were based on the professional opinions of Mackenzie Forest District staff and supporting data from regional analysts.

A.3 Timber Harvesting Land Base Definition

A.3.7 Roads, trails, and landings

Separate estimates were made to reflect the loss in productive forest land because of existing and future roads, trails and landings (RTL). Existing RTL estimates were applied as reductions to the current productive forest land considered available for harvesting, and future RTL reductions were applied after stands were harvested for the first time.

All highways and larger municipal roads were of a sufficient size to be mapped as polygons and classified as non-forest areas in the forest inventory file. These polygons were thus removed from the timber harvesting land base as non-forest area, as discussed in Section A.3.3, "Land classified as non-forest or non-productive forest." All other roads, trails and landings were depicted only as lines on forest cover maps, and had no associated polygons.

Table A-8. Estimates for existing and future roads, trails, and landings

Road status	Road length (metres)	Road width (metres)	Area reduction (hectares)
Existing RTLs			
Non-status	4 042 787	12	4 851
Mainline	1 126 970	20	2 254
Operational	1 247 480	10	1 247
Future RTLs			(hectares/year)
All	150 000	20	300
All	150 000	10	150

Data source and comments:

Non-status road information was collected through the Watershed Restoration Program. Mainline and operational road reductions (includes access and in-block roads) were compiled from the major licensee's 1994-1998 Road Construction Financial reports. Road width includes the running surface, ditch line plus the area cleared for visibility/safety concerns. A total reduction of 4.5% was applied to stands with a harvesting history for roads.

It is estimated that the major licensees will require 300 km of future road per year to access timber until the TSA is fully roaded by the currently 10 000 hectares per year harvest rate. Fifty per cent will be 20 metres wide and 50% will be 10 metres wide. The amount of future road was estimated at 450 hectares per year or a 4.5% reduction for future RTLs assuming an annual harvest of 10 000 hectares. These figures were based on information from the Mackenzie Forest District.

A.3 Timber Harvesting Land Base Definition

A.3.8 Cultural heritage resource reductions

An archaeological overview assessment of Mackenzie TSA was completed in 1997. This assessment is currently being refined to increase its operational utility. As part of their operational planning, the major licensees and the Small Business Forest Enterprise Program complete additional archaeological and cultural heritage assessments when appropriate.

Based on the studies to date, cultural heritage resources (both known and those identified in future inventory projects) will be protected or managed through the careful location of old-growth management areas, riparian reserves, wildlife tree patches, and other reductions to the timber harvesting land base. Furthermore, since natural succession changes the timing and location of traditional harvests of berries, herbs, medicinal plants, and wildlife, it is expected that changes induced through harvesting and silviculture can be accommodated in a similar manner. Therefore, no additional reductions were included to address this resource.

A.3.9 Wildlife habitat reductions

Some wildlife habitat areas were coded as ESAs, and were therefore partially excluded from the timber harvesting land base as described in Table A-6. The LRMP includes measures to protect caribou, grizzly bear, moose and mountain sheep habitat. Since the LRMP was not formally approved at the time of this analysis, these wildlife measures were be considered in the base case. The potential timber supply impacts of the LRMP recommendations were examined in sensitivity analysis.

The previous analysis for the Mackenzie TSA incorporated deferrals and old forest requirements for several areas of wildlife habitat, including the Upper Ospika Valley and Russell Range. These measures were not current practice at this time. However, provisions for maintaining old-seral forest to manage landscape-level biodiversity were believed to achieve many of the wildlife habitat objectives that the measures modelled in the last analysis were designed to achieve. In addition, the proposed LRMP contains significant wildlife management provisions, which were assessed in sensitivity analysis.

A.3.10 Riparian reserve zones

Regional BCFS staff studied the impact of *Forest Practices Code* provisions on three mapsheets in 1995 and recommended the reductions that were used in the analysis.

Table A-9. Riparian reserve and management zones

Location	Reduction per cent (%)
Riparian reserves	5.16
Riparian management zones	1.95
Regional lakeshore guidelines	0.06
Total reduction	7.17

Data source and comments:

After reviewing the three maps (93N.059, 93O.055 and 94C.035) it was found that only one stream that was previously unclassified had now been classified (map 93N.059, from unclassified to stream class S3 [500 m long * 2.39 m wide {avg. stream width}]). BCFS and MOELP representatives reviewed the information from the three mapsheets and were satisfied that the existing information was representative of the TSA. The deduction was applied equally to all stands after deductions discussed in previous sections have been performed.

A.3 Timber Harvesting Land Base Definition

A.3.11 Exclusions of specific, geographically defined areas

The Kemess power line and Kemess mine site were removed from the timber harvesting land base. The power line right-of-way is 70 metres wide and is shown as a power line on the forest cover inventory. The cleared area of the power line consists of 2827.4 hectares (gross) and 2280.9 hectares of timber harvesting land base as indicated in appraisals of the licences to cut. The gross area of the mine site is 7415.6 hectares as specified by the licence-to-cut (exhibit A) of which 938.6 hectares have been cleared.

The McLeod Lake treaty agreement has been signed-off by all parties. The treaty provides for transfer of approximately 21 000 hectares from the Crown land bases of the Prince George and Mackenzie TSAs to members of the McLeod Lake Band. There is also the option for a limited number of Band members to take land as individuals within the McLeod Lake traditional territory, mostly in the Prince George TSA. Only about 500 hectares of the area to be transferred is within the Mackenzie TSA. Details of the transfer of land were expected to be completed by Fall 2000. Since the details are uncertain at this time, no adjustments are planned for the Mackenzie TSA base case. Any impact of the treaty agreement on timber supply in the Mackenzie TSA will be considered in the AAC determination; however, given the small area involved in the Mackenzie TSA, the impact is likely to be negligible.

A.4 Current Forest Management Assumptions

A.4.1 Utilization levels

The utilization levels define the maximum stump height, minimum top diameter inside bark (dib) and minimum diameter at breast height (dbh) by species and were used in the analysis to calculate merchantable volume.

Table A-10. Utilization levels

Analysis unit	Utilization		
	Minimum diameter at breast height (cm)	Maximum stump height (cm)	Minimum top diameter inside bark (cm)
All conifer units	12.5	30	10
All deciduous units	12.5	30	10

A.4.2 Volume exclusions for mixed species stands

In the Mackenzie TSA, the deciduous species in predominantly coniferous stands are not normally harvested. As shown in Table A-11., the unharvested deciduous portion of coniferous-leading stands was not contributed to the estimated stand volumes.

Table A-11. Volume exclusions for mixed species types

Inventory type group	Species	Volume exclusion (%)
All coniferous leading	Deciduous	100

Data source and comments:

The exclusion pertains to only the deciduous timber volumes in coniferous-leading types. The deciduous trees may contribute to biodiversity and coarse woody debris objectives at the stand level. Deciduous-leading stands do contribute to the harvesting land base, except where excluded for other netdowns noted in the data package.

A.4.3 Minimum harvestable age derivation

The minimum harvestable age is the time required for stands to grow to harvestable size; it defines the lower limit for harvesting. Harvesting may occur in stands at the minimum age to meet a harvest target for a short period of time or avoid large and abrupt changes in harvest levels. However, most stands will not be harvested until well past the minimum ages to maximize long-term timber production, maintain consistent harvest flow and manage objectives for other resource values (e.g., requirements for the retention of older forest).

Information compiled for the minimum criteria to harvest in near and far zones is listed in Table A-12. for conventional, cable and helicopter logging.

A.4 Current Forest Management Assumptions

Table A-12. Minimum harvestable ages

Analysis unit	Species	Minimum harvestable age (years)	Culmination age (years)
Existing unmanaged conventional stands in near zone			
1	B	80	100
2	B	110	120
3	B	150	160
4	S	70	100
5	S	90	140
6	S	140	200
7	P	60	80
8	P	80	110
9	P	100	130
10	Po	60	60
11	As	60	60
12	Bi	60	60
Managed conventional stands in near zone			
101	B	70	110
102	B	90	150
103	B	120	190
104	S	55	90
105	S	70	120
106	S	130	200
107	P	50	70
108	P	60	90
109	P	90	130
Existing unmanaged conventional/cable stands in near zone			
21	B	90	100
22	B	130	120
23	B	190	160
24	S	80	100
25	S	110	140
26	S	170	200
27	P	70	80
28	P	90	110
29	P	120	130
Managed conventional/cable stands in near zone			
121	B	80	110
122	B	100	150
123	B	130	190
124	S	60	90
125	S	80	120
126	S	140	200
127	P	55	70
128	P	80	90
129	P	110	130

(continued)

Table A-12. Minimum harvestable ages (continued)

Analysis unit	Species	Minimum harvestable age (years)	Culmination age (years)
Existing unmanaged cable stands in near zone			
31	B	110	100
32	B	160	120
33	B	230	160
34	S	90	100
35	S	120	140
36	S	200	200
37	P	80	80
38	P	110	110
39	P	140	130
Managed cable stands in near zone			
131	B	80	110
132	B	110	150
133	B	140	190
134	S	65	90
135	S	90	120
136	S	160	200
137	P	60	70
138	P	90	90
139	P	140	130
Existing unmanaged conventional stands in far zone			
41	B	90	100
42	B	130	120
43	B	190	160
44	S	80	100
45	S	110	140
46	S	170	200
47	P	65	80
48	P	80	110
49	P	110	130
Managed conventional stands in far zone			
141	B	75	110
142	B	100	150
143	B	130	190
144	S	60	90
145	S	80	120
146	S	140	200
147	P	50	70
148	P	70	90
149	P	100	130

(continued)

A.4 Current Forest Management Assumptions

Table A-12. Minimum harvestable ages (concluded)

Analysis unit	Species	Minimum harvestable age (years)	Culmination age (years)
Existing unmanaged conventional/cable stands in far zone			
51	B	110	100
52	B	160	120
53	B	230	160
54	S	90	100
55	S	120	140
56	S	200	200
57	P	80	80
58	P	100	110
59	P	140	130
Managed conventional/cable stands in far zone			
151	B	80	110
152	B	110	150
153	B	140	190
154	S	65	90
155	S	90	120
156	S	160	200
157	P	60	70
158	P	85	90
159	P	140	130
Existing unmanaged cable stands in far zone			
61	B	130	100
62	B	190	120
63	B	250	160
64	S	100	100
65	S	140	140
66	S	220	200
67	P	90	80
68	P	120	110
69	P	190	130
Managed cable stands in far zone			
161	B	90	110
162	B	120	150
163	B	155	190
164	S	65	90
165	S	95	120
166	S	180	200
167	P	65	70
168	P	100	90
169	P	160	130

A.4 Current Forest Management Assumptions

A.4.4 Harvest scheduling priorities

Priority for harvest was highest for stands that were the oldest relative to the applicable minimum harvestable age. This is termed a "relative oldest first" harvest rule.

A.4.5 Logging method

The primary logging method in the Mackenzie TSA is conventional, ground-based harvesting.

Table A-13. Logging method

Logging method	Per cent (%) of annual harvested area
Conventional	86
Conventional/Cable	5
Cable	7
Helicopter/Combination	1
Helicopter	1

Data source and comments:

The figures were based on the per cent of annual harvest per year (1994 to 1998) by major licensees and the Small Business Forest Enterprise Program.

A.4.6 Silvicultural systems

Clearcutting was the harvest method used for all analysis units within the Mackenzie TSA. Silviculture prescriptions (SPs), and the Ministry of Forests computerized tracking systems (FTAS and MLSIS) indicated that a significant number of openings were clearcuts with reserves. These openings were clearcuts, with riparian reserves and wildlife tree patches forming the "reserves" identified in the silvicultural system label. The reserves were included in the land base not available for harvesting. Therefore, clearcuts with reserves were modelled as clearcuts.

A.4.7 Unsalvaged losses

Table A-14. shows the estimated average annual unsalvaged volume loss to catastrophic events such as insect epidemics, and fires, on the timber harvesting land base. The unsalvaged loss column reflects only those volumes which were not recovered or salvaged.

Table A-14. Unsalvaged losses

Cause of loss	Unsalvaged losses (m^3/year)
Fire	39 900
Spruce bark beetle	91 600
Balsam bark beetle	40 500
Mountain pine beetle	800
Total	172 800

A.4 Current Forest Management Assumptions

Data source and comments:

Unsalvaged losses resulting from fire and balsam bark beetle (Table A-14.) were determined using the ratio of timber harvesting land base and crown forested area from the LRMP database. Fire losses were determined using data from 1988 to 1998 from the Protection Branch fire reporting system. The 1998 fire data were collected by district staff. Gross volume losses for fire were based on ocular estimates and district staff experience.

Estimates of spruce and balsam bark beetle losses were based on data collection and mapping of attacked areas for ten-year and eight-year periods, respectively. Mountain pine beetle is a relatively new problem in the Mackenzie TSA and has been tracked for three years. Data collection for budworm has not been completed; however, the effects of budworm damage were factored into the yield curves for unmanaged stands. No information was available regarding unsalvaged losses for wind damage in the Mackenzie TSA.

A.4.8 Regeneration activities

The silviculture program reflects the mix of treatments expected to be carried out to achieve basic silviculture on all sites. Table A-15. shows the proportion of each analysis unit to be treated under each silviculture regime.

Recent plantations and future stands were projected using managed stand yield tables (MSYTs) produced using the Forest Service table interpolation program for stand yields (TIPSY) growth and yield model. A MSYT may be built from a number of tables if more than one regeneration method was used within an analysis unit. When this was the case, tables were produced for the different regeneration methods (each method and species combination) and then combined into one table.

Table A-15. Regeneration assumptions by analysis unit

Analysis unit	Species composition	Regen delay (years)	OAFs (%)		Regen method	Regen species	Per cent (%)	Density initial (sph)
			1	2				
1, 2, 3	Balsam	3	15	5	Plant	Spruce	100	1400
4, 5, 6	Spruce	3	15	5	Plant	Spruce pine	80 20	1400
7, 8, 9	Pine	3	15	5	Plant	Pine	100	1300
10, 11	Poplar/ cottonwood	3	15	5	Natural	Poplar/ cottonwood	100	1400
12, 13	Aspen	3	15	5	Natural	Aspen	100	1400
14, 15	Birch	3	15	5	Natural	Birch	100	1400

Data source and comments:

Operational adjustment factors (OAFs) were used to adjust timber yield estimates to account for operational factors. OAF1 is a constant percentage reduction to account for small stocking gaps within stands. OAF2 accounts for losses that increase with stand age, for example decay due to disease. In this case OAF2 increases from 0 at stand establishment and passes through 5% at 100 years of age. Provincial average operational adjustment factors (OAFs) values were applied to the managed stand yield curves as recommended by the Ministry of Forests, Research Branch, as no local OAFs were available.

A.4 Current Forest Management Assumptions

A.4.9 Managed stands and regeneration assumptions

Existing managed stands were those areas of immature forest where the density (stems per hectare) was controlled which justifies assigning the stands to managed stands yield tables (MSYT). Table A-16. shows the criteria for the selection of existing managed stands.

Table A-16. Existing managed stands

	Area managed/unmanaged (%)			
	Age 1-12	**Age 13-20**	**Age 21-30**	**Age 31-40**
Managed	100	60	60	60
Unmanaged	—	40	40	40

Data source and comments:

Data were obtained from the Integrated Silviculture Information System (ISIS) and the Major Licensee Silviculture Information System (MLSIS). Growth for managed stands was projected using TIPSY, where information was available. The unmanaged portion was projected using VDYP.

A.4.10 Forest cover objectives

As noted in Section A.2.1, "Management zones, groups and multiple objectives," forest cover requirements were applied to a number of different types of areas including landscape units, wildlife areas, or visual quality areas. Forest outside of the timber harvesting land base was contributed to some forest cover requirements (i.e., maximum allowable disturbance or minimum area retention). The following forest cover requirements were applied to each resource emphasis group within each landscape unit.

Table A-17. Forest cover requirements for VQOs

	Forest cover objectives				
Resource emphasis	**Green-up height (metres)**	**Green-up maximum allowable disturbance (%)**	**Minimum older age (years)**	**Minimum area of older age retained (%)**	**Land base constraints apply to**
Visual quality — retention	3	3	N/A	N/A	Crown forested area
Visual quality — partial retention	3	10	N/A	N/A	Crown forested area
Visual quality — modification	3	20	N/A	N/A	Crown forested area
Visual quality — maximum modification	3	32.5	N/A	N/A	Crown forested area

A.4 Current Forest Management Assumptions

To ensure that older forests are maintained throughout the TSA, forest cover requirements were applied to each biogeoclimatic variant within each draft landscape unit. The landscape units were not yet finalized; however, as the draft units were available in digital format they were used as a modelling tool to simulate the geographic retention of older forest characteristics across the Mackenzie TSA. This did not imply these units were final.

A process to formally establish biodiversity objectives for each landscape unit is currently underway and will be completed over the next several years. As a first step in this process, interim biodiversity emphasis options (BEOs) were developed by Mackenzie Forest District staff in consultation with MELP staff and licensees for approximately two-thirds of the TSA. While these interim BEOs have not been formally designated, they are currently being used in development plan approvals. The interim BEOs were incorporated in the base case for the Mackenzie TSA. Draft BEOs and landscape unit boundaries for use in the regional landscape unit planning (RLUP) process were approved by the Mackenzie Forest District Manager and the designated environment official.

Table A-18. Forest cover requirements for resource emphasis areas

			Mature and old-seral stage		Old-seral stage	
Biogeoclimatic unit	NDT	Biodiversity emphasis	Minimum retention area (%)	Minimum age (years)	Minimum retention area (%)	Minimum age (years)
BWBS	3	Low			11	140
BWBS	3	Medium	12	120	11	140
BWBS	3	High	18	100	16	140
ESSF	1	Low			19	250
ESSF	1	Medium			19	250
ESSF	1	High			28	250
ESSF	2	Low			9	250
ESSF	2	Medium			9	250
ESSF	2	High			13	250
SBS	2	Low			9	250
SBS	2	Medium			9	250
SBS	2	High			13	250
SBS	3	Low			11	140
SBS	3	Medium	12	100	12	140
SBS	3	High	18	100	16	140
SWB	2	Low			9	250
SWB	2	Medium			9	250
SWB	2	High			13	250

A.4 Current Forest Management Assumptions

A.4.11 Reduction to reflect volume retention in cutblocks

Wildlife tree patches (WTPs) are the primary method used by major licensees to maintain mature stand structure elements over time. Plans are to maintain WTPs for one rotation. If harvested before that time WTPs of comparable size and structure will be identified as replacements.

An area reduction was used to model wildlife tree patch requirements because it more accurately reflects current management and thus the area upon which harvesting would occur. These wildlife tree patches, in conjunction with other riparian reserves and area removals, are generally larger than two hectares and are left to maintain stand structure within the landscape over time. As the wildlife tree patches are larger than two hectares, this area will contribute to meeting seral-stage forest requirements at the landscape level. It was assumed that wildlife tree patches would not be economical to harvest at a later date, and would be retained as WTPs during subsequent harvests of the stand.

Table A-19. Reductions to reflect volume retention in cutblocks for wildlife tree patches

Management zone	Analysis unit	Persistence	Per cent (%) recommended in applicable guidebook	Residual area estimate on the timber harvesting land base (%)
All	All	Long term	8	4

A.5 Volume Estimates for Existing Stands

The variable density yield projection (VDYP) model, Version 6.5a developed and supported by the B.C. Ministry of Forests, Resources Inventory Branch, was used to estimate timber volumes for existing natural stands. Table A-20. shows the volume estimates by analysis unit for existing natural stands.

The yield tables were the same for the near haul zone and far haul zone, conventional, conventional/cable and cable logging system. But their minimum harvestable ages are different.

Table A-20. Timber volume tables for existing natural stands (cubic metres/hectare)

Age (years)	Analysis unit					
	1	2	3	4	5	6
10	0	0	0	0	0	0
20	0	0	0	0	0	0
30	12	3	0	1	0	0
40	35	15	7	17	1	0
50	69	33	18	68	11	1
60	101	57	32	117	41	2
70	133	84	53	162	79	9
80	159	105	70	201	114	24
90	183	124	84	236	147	44
100	204	141	98	265	176	66
110	223	156	110	291	202	88
120	241	171	122	313	226	108
130	260	186	134	333	248	129
140	278	201	146	350	268	147
150	295	215	157	365	285	165
160	310	228	168	377	300	181
170	324	240	179	386	313	196
180	338	252	189	395	324	210
190	351	263	198	401	334	223
200	363	274	207	408	344	235
210	375	285	216	414	353	246
220	386	295	225	419	361	257
230	397	305	233	424	368	267
240	408	314	241	429	375	276
250	418	323	249	433	381	285
260	420	325	251	436	386	292
270	422	327	252	439	390	298
280	424	328	253	441	394	303
290	425	330	254	443	397	309
300	427	331	255	445	401	313
310	428	332	256	447	404	318
320	430	333	257	449	406	322
330	431	335	257	450	409	326
340	432	336	258	451	411	330
350	433	337	259	452	413	333

(continued)

A.5 Volume Estimates for Existing Stands

Table A-20. Timber volume tables for existing natural stands (cubic metres/hectare) (concluded)

Age (years)	Analysis unit					
	7	8	9	10	11	12
10	0	0	0	0	0	0
20	0	0	0	1	0	0
30	20	1	0	19	6	5
40	71	32	5	48	34	31
50	117	72	33	79	67	65
60	158	108	64	107	97	97
70	194	141	92	129	124	126
80	226	171	118	148	147	150
90	254	198	142	164	167	171
100	280	222	164	177	185	189
110	304	245	185	189	202	203
120	326	266	204	198	216	214
130	346	286	223	207	226	222
140	360	300	236	214	231	230
150	370	310	246	220	236	236
160	378	318	254	221	240	239
170	382	323	260	222	243	241
180	383	325	263	223	246	242
190	382	325	263	224	248	243
200	384	328	266	225	251	245
210	387	330	270	226	253	246
220	389	333	273	227	255	247
230	392	336	276	227	257	248
240	394	338	278	228	259	249
250	396	341	281	229	260	250
260	398	343	283	229	261	251
270	400	345	285	229	261	251
280	402	347	287	230	262	252
290	404	348	288	230	262	252
300	405	350	290	230	263	253
310	407	351	291	230	263	253
320	408	352	292	231	263	253
330	409	353	293	231	264	254
340	410	354	294	231	264	254
350	411	355	294	231	264	254

A.6 Volume Estimates for Regenerated Stands

WinTIPSY (Windows™ version of the Table Interpolation Program for Stand Yields) version 1.4, supported by the B.C. Ministry of Forests, Research Branch, was used to estimate growth and yield for existing and future managed stands. The area-weighted site index for each analysis unit along with the regeneration assumptions in Table A-15. were used as inputs to TIPSY. Table A-16. in Section A.4.8 document which stands were assumed to be managed in the analysis.

Table A-21. displays the volume tables for managed stands. These volume tables are generated from TIPSY for ages where TIPSY data exist, and estimated for ages beyond the TIPSY data set. Volumes are assumed to remain constant after 200 years of age.

Table A-21. Timber volume tables for existing and future managed stands (cubic metres/hectare)

	Analysis unit								
Age (years)	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**
10	0	0	0	0	0	0	0	0	0
20	0	0	0	1	0	0	4	0	0
30	0	0	0	13	5	0	53	17	2
40	9	0	0	66	20	0	121	55	19
50	52	5	0	139	51	1	174	105	46
60	111	26	3	213	98	5	235	141	77
70	173	65	13	275	145	12	278	174	107
80	226	108	42	340	194	23	314	211	130
90	274	152	75	386	237	48	344	241	150
100	327	193	110	417	277	75	367	264	169
110	369	228	144	440	316	102	386	284	189
120	399	262	179	458	353	128	403	301	208
130	421	298	208	474	380	155	417	316	225
140	438	333	235	486	401	180	428	329	238
150	451	359	261	495	417	201	436	338	248
160	463	381	289	499	429	222	443	347	258
170	473	396	317	500	440	241	449	355	267
180	482	410	340	500	449	263	455	361	274
190	487	421	359	500	456	284	455	367	280
200	492	429	375	500	463	303	455	371	286

Appendix B

Socio-Economic Analysis Background Information

B.1 Limitations of Economic Analysis

The socio-economic analysis identifies employment and income impacts, changes in government revenues and community impacts at various harvest levels and times in the future. Some of the assumptions used in the analysis are as follows:

- **Employment multipliers** — these multipliers are used to estimate indirect and induced employment impacts of a change in direct industry activity. Employment multipliers are calculated based on analytical assumptions and data collected at a specific time. Consequently, the multipliers reflect industry and employment conditions at that time and may not accurately reflect future industry conditions. While generally sound indicators when based on fairly recent information, older multipliers can be dated and may not reflect industry conditions at the time of analysis. In any impact analysis, the information should be considered as indicators of size of change.
- **Employment coefficients** — employment impacts associated with future harvest levels are calculated using employment coefficients (person-years per 1000 cubic metres). This approach assumes that the industry structure will be the same in future as it is today. While reasonably accurate in the short term, employment coefficients may change in future as a result of changing market conditions or production technologies, for example.
- **Timing of impacts** — employment impacts are shown to occur simultaneously with a change in the harvest level. While fairly accurate for the harvesting sub-sector, this may not be the case for the processing and silviculture sub-sectors of the forest industry. Also, indirect and induced impacts will likely occur over a longer period, as business and consumer spending levels adjust to changes in harvest levels.
- **Processing thresholds** — processing job impacts are unlikely to occur in direct proportion to harvest changes (i.e., a 10% harvest reduction may not lead to a 10% processing employment reduction). Impacts are more likely to occur stepwise related to processing thresholds. A processing threshold is the level of a mill's timber supply where, when reached, will cause a mill to either lay off a shift or shut down the mill, temporarily or permanently. Accurately predicting a mill's threshold level is impossible. As a result, the analysis may overestimate processing impacts if a mill continues to operate the same number of shifts, but perhaps at lower production levels, or alternatively could underestimate impacts if a mill were to eliminate a shift. Over the medium- to long-term the impact figures should be reasonably accurate, however.
- **Government expenditures** — provincial government expenditures are more related to population levels than to industry activity. As such, expenditures on education, health care and other government services are assumed to remain unchanged despite harvest changes and any subsequent change in government revenues. However, public expenditures would likely change if community population levels change sufficiently. This shift would amplify the community impacts of forestry job losses or gains.
- **Proportional harvest reductions** — harvest reductions are assumed to be spread proportionately among all licensees and all forms of tenure.

B.2 Economic Impact Analysis Methodology

Data sources

Data for the socio-economic analysis were obtained from several sources. Harvest volume and stumpage data are from the Ministry of Forests. Timber flow and employment data are from responses to questionnaires that were sent to licensees, operators and processing facilities in the TSA. Other general economic data are from B.C. Stats, the Ministry of Finance and Corporate Relations, Statistics Canada and local communities.

Person-year of employment

The unit of measurement for employment is a person-year. A person-year of employment is defined as a full-time job, which lasts at least 180 days per year. Part-time jobs were converted to equivalent full-time person-years of employment. To estimate employment and income impacts associated with changes in TSA timber harvest levels, the forestry sector was divided into three sub-sectors:

1. harvesting;
2. silviculture; and
3. timber processing.

Estimating employment and income impacts involves several steps. First, the current activity in each of the three sub-sectors was assessed. Then, indirect and induced employment and employment income impacts were estimated, using data from the Ministry of Finance and Corporate Relations, and Statistics Canada. Next, employment coefficients were calculated and applied to the base case harvest forecast. Other indicators of the forestry sector's contribution to the provincial economy, such as government revenues and industry taxes, were also calculated using Ministry of Forests stumpage estimates and other data sources.

Employment — harvesting

Direct employment in harvesting consists of all woodlands-related jobs including harvesting, log transport, log salvage, planning and administration functions. The employment multipliers used in this analysis define road building and maintenance work as indirect rather than direct employment. Including this employment in direct estimates would result in double counting.

Data on employment, place of residence and timber flows were obtained through a survey of licensees and operators in the TSA. The information was then used to estimate employment averages associated with harvest changes and the proportion of resident *versus* non-residents who work in the TSA.

Two estimates of direct employment in harvesting were calculated:

1. TSA direct employment in harvesting consists of employees who are engaged in harvesting and related activities within the TSA and who reside in communities within the TSA; and
2. Provincial direct employment in harvesting consists of employees who are engaged in harvesting, as above, plus those workers who reside outside the TSA, but who come to the TSA to work in harvesting and harvesting-related activities.

The estimates of TSA and provincial direct employment in harvesting were used to calculate employment coefficients per 1000 cubic metres. These employment coefficients were then used to estimate harvesting employment associated with the different harvest levels in the base case forecast.

B.2 Economic Impact Analysis Methodology

Employment — silviculture

Silviculture employment consists of all basic and intensive reforestation activities, including surveys, site preparation, planting, fertilization, pruning and spacing. Silviculture employment data were collected from the Ministry of Forests and licensees whose tenures require post-harvest silviculture work. Most silviculture work is seasonal and silviculture employees usually only work part-time during the year. Because of this, silviculture jobs were converted into equivalent full-time person-years of employment. Respondents were also asked to estimate the percentage of their silviculture employees who resided within the TSA and outside the TSA.

As with the harvesting sub-sector, two estimates of direct employment in silviculture were calculated: one for the TSA and another for the province. These employment figures were used to calculate employment coefficients for silviculture employment in the same manner as the employment coefficients for harvest employment.

Employment — timber processing

Information about employment, production and sources of timber was gathered from TSA mills. Information was also gathered as to whether timber harvested from the TSA was processed within the TSA or outside the TSA. This information indicates the degree of dependence the mills have on timber harvested within the TSA. To estimate the share of processing employment supported by TSA timber, mill employment was prorated by the relative contribution of timber from the TSA to a mill's total timber requirement. For example, if 80% of a plant's timber requirement was supplied by the harvest from the TSA, then 80% of the employment in the plant would be attributable to the TSA harvest.

Employment figures were also adjusted to reflect the residences of workers: those who lived within the TSA and those who lived outside the TSA. Employment in timber processing that is supported by chip by-products from milling operations was also estimated similarly.

As with the harvesting sub-sector, two estimates of direct employment in timber processing were calculated: one for the TSA and another for the province. These employment figures were used to calculate employment coefficients for timber processing employment in the same manner as the employment coefficients for harvest employment.

Indirect and induced employment estimates

Indirect employees associated with the forestry sector are those who supply goods and services to firms directly engaged in the basic forestry sector (for example, those who provide road maintenance services, fuel and office equipment and products). Induced employment consists of those who supply goods and services purchased by employees who are directly and indirectly engaged in the industry (for example, those who work in retail outlets). Indirect and induced employment figures were calculated using TSA and provincial employment multipliers developed by the Ministry of Finance and Corporate Relations.

Two sets of employment multipliers were used for this report: migration multipliers and no-migration multipliers. The migration multipliers assume that displaced workers will leave the region, reducing total income in the region by their full wage. The no-migration multipliers assume that displaced workers remain in the area, at least in the short term, and unemployment and other social safety net payments temporarily offset some of the income loss. Using the no-migration multipliers diminishes the induced impacts associated with a change in direct employment.

B.2 Economic Impact Analysis Methodology

The TSA and provincial employment multipliers used in the Mackenzie TSA analysis are shown in Table B-1.

Table B-1. Total employment multipliers

Forest sub-sector	TSA migration multiplier	TSA no-migration multiplier	Provincial interior migration multiplier	Provincial interior no-migration multiplier
Harvesting	1.34	1.21	2.14	1.80
Solid wood processing	1.30	1.17	2.29	1.93
Pulp	1.51	1.36	3.02	2.48

Sources: Horne, G., R. Riley, L. Ransom, and S. Kosempel. 1996. A provincial impact estimation procedure for the British Columbia forest sector. B.C. Ministry of Finance and Corporate Relations, Victoria, B.C. 40 p.

B.C. Ministry of Finance and Corporate Relations, Victoria B.C. 1999. *The 1996 forest district tables.*

Employment estimates of alternative timber supply levels

To estimate employment generated by alternative timber supplies, the forecast harvest level is multiplied by the calculated employment coefficients. Note that employment coefficients are based on current industry productivity, harvest practices and forest management assumptions and will not likely reflect industry operating conditions in the future. Therefore, the employment estimates should be viewed as indicators of the size of change rather than as precise estimates of changes in employment levels.

Estimates of employment income

Employment income was calculated using average income estimates for workers in the forest industry. Income data are from Statistics Canada annual estimates of employment, earnings and hours. From 1997 to 1999, the average pre-tax annual income (less benefits) for sub-sectors of the forestry sector associated with the Mackenzie TSA was about $46,800 for logging and forestry services; $46,200 for solid wood manufacturing; and $55,900 for the pulp and paper sector. The weighted average annual income for direct forestry workers in the Mackenzie TSA was $48,550. The average annual income for indirect and induced workers averaged about $30,300. This figure is based on data for all service-producing industries from the Statistics Canada Labour Force Survey estimates for B.C. Income taxes were calculated based on marginal tax rates of 23–28% with one-third of the total income tax accruing to the province.

B.2 Economic Impact Analysis Methodology

Provincial government revenues

Except for stumpage, royalty and rents, which are specific to the TSA, provincial government revenue impacts were estimated by using industry averages. Revenues per 1000 cubic metres of harvest, expressed as dollars per 1000 cubic metres, were calculated and applied to the harvest levels in the base case forecast in a manner similar to how employment impacts were estimated. Table B-2. summarizes provincial government revenue estimates.

Table B-2. Estimates of provincial government revenue, Mackenzie TSA

Source of revenue	Average revenue 1997-1999 ($1998 millions)	Revenue ($/'000s m^3)
Stumpage, rents and royalties[a]	67.1	25,750
Industry taxes[b]	23.4	9,040
Provincial income tax[c]	15.0	5,780
Total government revenues	105.5	40,570

(a) Ministry of Forests.

(b) PriceWaterhouseCoopers.

(c) Based on marginal tax rates from Revenue Canada.